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A STUDY OF BEAVER COLONIES IN MICHIGAN

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Perhaps no other north American mammal has given rise to so many stories or to so voluminous a literature as has the beaver. Hearne (1795), Morgan (1868), Dugmore (1914), Bailey (1927), Seton (1929), Warren (1929), and others have written entertainingly about the manifold details of the beaver's life and its feats of engineering.

In view of this abundance of literature, it was with some trepidation that I began an investigation into certain phases of the life history and ecology of the beaver in Michigan. I was soon surprised to discover that most of the literature was of the casual observational, or "nature study" type, replete with references to statements made by Indians, fur trappers, and old woodsmen, corroborated or refuted by occasional personal observations and experiences. Very little planned research work seemed to have been done.

With the return of the beaver to a position of economic importance in Michigan, the state Department of Conservation was confronted with various problems concerning beaver populations and relationships, and it soon became evident that more accurate and intensive knowledge of the beaver was essential, if proper regulatory measures were to be adopted.

In cooperation with the Game Division of the Department of Conservation, I began an investigation of the beaver situation in the spring of 1929, which has continued to the present time. I have been able to spend a considerable portion of my summer vacation periods in the field each year, with occasional field trips during the school year, and have also maintained a small colony of beavers in captivity at the State College campus in East Lansing.

The first step necessary was to develop methods of catching the animals alive, determining the sex, marking them so that they could be individually identified if recaptured, and releasing them without serious losses from fright or injury.

Livetraps.—Fortunately, live traps were already available and could be purchased. The Biological Survey beaver trap, devised and described by Vernon Bailey (1927), was used successfully during the earlier part of the investigation. The trap was later replaced to a great extent by an aluminum alloy trap, much lighter and easier to handle than the former iron traps. These traps proved entirely satisfactory in every respect, rarely failing to catch a beaver when properly adjusted and suitably placed.

Beaver traps may be set in a variety of positions, according to conditions of water, food, runways, and other factors. The set most often used is prepared by tearing away a small section of a beaver dam to a depth of about one foot and a width of about two feet, permitting the water to pour through the opening in a miniature cascade. The trap is then placed just behind the opening, upstream, so that the beaver will swim against the trigger in approaching to repair the break in the dam. Since beavers are very active in repairing any breaks in their dams, this set can be depended upon to produce results in a high percentage of cases, and can be used night after night until all members of a colony using the dam have been taken. Beavers are so little disturbed by live trapping that they will often repair a dam a few feet from where one of their number is caught in a live trap, even pushing sticks against the trap in placing them in position on the dam. The set at the dam also offers the advantage of comparatively easy access in setting the traps and removing the captive animals.

Traps may be set at the foot of runways down which the beavers bring cuttings for use as food or in construction work. There is a distinct disadvantage in this method of setting a trap, however, since the poles or sticks carried by the beavers often spring the trap prematurely, or prevent the jaws from closing tightly, permitting the animal to escape. If the stream happens to be of the proper depth and width, traps may be set in the channel, catching the beaver as it swims up or down stream. A trap may be set on the base of a beaver lodge, catching the animal as it feeds or carries sticks to add to the lodge.

Traps must always be placed under water, as beavers are very suspicious of strange objects above the surface, but apparently they are quite oblivious to anything beneath the surface.

Occasionally it is desirable to attract the animals to a trap by the use of bait. This occurs most often when the beaver colony is located on a stream too large or too swift for the animals to dam, or on a lake or large pond where there is either no dam at all, or the dam is a considerable distance from the lodge or bank burrows in which beavers are dwelling. A simple method of baiting in such cases is to cut a number of fresh, leafy poplar shoots or twigs, and stick these into the bottom around the trap, with one or two close beside the trigger. The sight or smell of these freshly cut shoots is very attractive to beavers, who seldom fail to spring the trap while attempting

to sample the new food supply. Care must be taken to place the shoots in such positions that they will not interfere with the closing of the jaws of the trap, and where the beaver will be likely to swim against the trigger in investigating the fresh food material.

The use of bait is often necessary if one is to capture kit beavers still remaining in the lodge after the mother has been taken. Such kits are able to swim out and secure their own food after about the second week of life. These young animals may pay no attention to a broken dam, nor follow any regular channels or runways, but will search for any nearby food supply, and are easily taken in baited traps set near the lodge.

Losses of animals by injury in live traps is uncommon, such losses as do occur usually resulting from drowning. The traps sometimes tip over on one side, or slide down the slope behind the dam or lodge, covering the wire cage with water and of course drowning the unfortunate occupant. Such losses can nearly always be prevented, by tying the trap to a stake, and preparing the bed of the pond or stream properly for the reception of the trap before setting. Only 16 beavers from a total of 270 taken during the summer of 1931 were drowned, and many of these could have been saved by sufficient preventive forethought (Bradt, 1935, p. 512).

Handling and transporting beavers.—Various methods were tried for handling and transporting captured beavers from the pond or stream to a suitable place for sex determination and individual marking. The original iron frame traps were heavy and cumbersome to carry, and when these were in use the beaver was generally changed to a carrying case near the point of capture, and carried in this to the car, a matter of rods or miles as the case might be. To effect the change from trap to box, a rope or strap was slipped around the base of the tail while the beaver was still in the trap, then the jaws were opened and the animal swung into the open box. With the advent of the lighter, more compact aluminum frame traps, the trap was simply carried with the beaver inside. In case a trip of a mile or more was involved, a couple of poles were cut and tied on either side of the trap, permitting one man to walk at each end between the poles. Two men were not always available, however, and unaided I have carried many beavers in the aluminum traps for considerable distances.

There is little difficulty in catching beavers alive, but a great deal of hard work is involved, since the ponds and streams inhabited by them are often located at long distances from roads or trails, and often a thick cedar swamp or alder thicket must be penetrated before the water is reached.

Identification of sex.—Since there are no external indications of sex in beavers, a technique for field identification of sex had to be developed. Adult female beavers may be recognized during the nursing period and during the late stages of pregnancy by the four teats on the breast, but at other times of year the teats are inconspicuous and difficult to find.

The male beaver has a small os penis about one inch in length, which may be felt by inserting the finger into the genital opening just ventral to the anus. After some practice I was able to determine sex readily by this method except in the case of animals less than one year old. In the latter, the openings are so small that the insertion of the finger is not practicable.

This method requires that the animal be firmly held during the operation. This was accomplished by the use of a rectangular wooden box about 40 inches in length and 10 to 12 inches in diameter, closed at one end and open at the other. This box was set on end, with the open end upward. The beaver was then seized by the tail, held above the open end, and partly dropped, partly pushed head first into the box. With practice, this becomes a simple operation. A beaver held by the tail is unable to double upon itself sufficiently to bite the hand that holds it. It must, however, be held at arms length away from the body or it may bite some portion within reach, and the bite of a beaver is of serious consequence. Considerable muscular strength is required to poise a large beaver at arms length over the end of a box 40 inches above ground, the animal squirming violently meanwhile. A cylindrical tile of the proper diameter and length makes an excellent box for sex determination, as the smooth sides reduce friction and the beaver cannot resist so effectively when dropped into the opening.

Once inside the box or tile, the beaver is comparatively helpless, as it cannot turn around, and can be prevented from backing out. The tail is then held aside, the hind feet held also, and the operator proceeds with the sexing operation. An assistant is necessary to hold the box upright, and to hold either the feet or tail, the operator holding the member not so held. The beaver is a powerful animal, and if a box is used it must be strongly built and reinforced to withstand the struggles of the imprisoned animal. While the beaver is securely held in the box the marking operation is also accomplished.

Tagging.—The development of a satisfactory method of marking beavers so that individual animals could be readily recognized if recaptured proved to be a protracted and sometimes disheartening problem. The physical characteristics and habits of beavers prevent the use of the customary methods of tagging and marking live animals. The ears are very small, and too difficult of access to permit tags or punched holes to be practical. Bands placed on the legs would soon be torn off. Clipping of toe nails would be difficult to accomplish under field conditions, would require careful inspection of the animals under equally difficult conditions if recaptured, and might handicap them in swimming or feeding. No method involving damage to the pelt would be desirable. Only the flat scaly tail seemed suitable for marking.

Before I began this study Mr. H. D. Ruhl had already marked several beavers by riveting aluminum tags through the tail, and had released these

animals on the Gladwin State Game Refuge (Ruhl and Lovejoy, 1930). These tags were of the standard cattle ear tag type, bearing the words "Notify Conservation Department", and an individual number stamped on each one. A hole was punched through the tail of the animal, and the tag quickly riveted in position. A few taps with a hammer leveled the edges and made a neat looking and close fitting tag. The entire operation could be completed in less than 5 minutes, and the beavers seemed to mind it very little. A slight flinch as the punch penetrated the tissues of the tail, and occasionally a few drops of blood, were the only discernible effects.

Several of the tagged beavers were recaptured at intervals during the first year after release, and the tags were easily read and firmly in place. Apparently the problem of individual identification had been solved. Several hundred beavers were accordingly tagged and released during the nuisance beaver control work of 1931 (Bradt, 1933).

Unfortunately, about this time evidence began to accumulate indicating that after a year or so the flesh immediately surrounding the tag sloughs off, the tag loosens and falls out, leaving a rough hole to show that a tag had once been there, but leaving no clue as to the missing number on the lost tag.

Branding.—As soon as it became evident that the tail tagging method was a failure, branding methods were tried. Branding irons of suitable size were constructed, and a number of beavers on the Gladwin Refuge were caught, branded and released. Many of these had previously been tagged, and their identity had not been completely lost. The operation of branding proved unexpectedly simple. The white hot iron could be held against the surface of the tail until the white flesh beneath the scales was reached, yet the animal would never flinch. Apparently the surface and subsurface of the tail are not supplied with many nerve endings transmitting the sense of pain. The branding operation creates much smoke and odor, but in no case have I observed evidence of pain on the part of the beaver during the operation.

Brand numbers were easily read when fresh, and could even be seen when the beavers were swimming under water in the holding pen. Following the lapse of a year, however, only those numbers made up of straight lines, i.e. 1 and 7, could be accurately deciphered. Others were marred and obscure, due to a shedding or sloughing away of the scaly surface adjacent to the curves and angles.

Combinations of the figures 1 and 7 seemed adequate for the limited numbers of animals on the Gladwin Refuge, in which I was particularly interested at the time, and I continued to brand accordingly. These combinations were inadequate for any large number of beavers, however, and I soon adopted a code system, which avoids the use of the figure 7, as the angle of a 7 occasionally becomes so blurred as to occasion doubt as to the exact figure in question. With the code system a very large number of beavers

may be branded, using a single branding iron, and eliminating all curves and angles entirely. This system is illustrated in the accompanying diagram (Figure 1). Beavers marked with combinations of 1 and 7 in 1932 and 1933 still carried the brands in 1935 in an easily readable condition.

Places of study.—My first studies of beavers were conducted on the Gladwin State Game Refuge, located in the northwest corner of Gladwin County. The first beavers tagged in Michigan were liberated on this refuge by Mr. Ruhl in the fall of 1928, and here I carried on many of my subsequent investigations. Later the refuge was also used as a center for the investigation of beaver-trout relationships by J. C. Salyer (1935) and myself.

During the summer of 1931, I was engaged in the nuisance beaver control operations undertaken by the Department of Conservation and was able to accumulate much valuable information regarding beaver populations and distribution, as all reports were made on uniform blanks and these, including

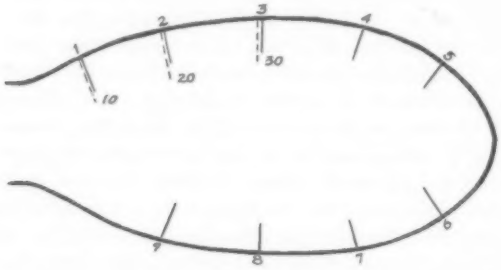

Diagram of the tail branding method used on beaver. Twin numbers, as 11, 22, 33, should be omitted.

those made by other workers as well as my own, were made available to me. A brief summary of this work was published in 1933 (Bradt, 1933, p. 509) (See also Table 1).

The summer of 1934 was spent in the field in northern Michigan carrying on a part of the beaver-trout investigation, and during the summer of 1935 I was in the field in charge of the newly inaugurated beaver-trout management program of the Department of Conservation.

Examination of carcasses.—In connection with this program, 207 beaver carcasses were purchased by the Department of Conservation from trappers during the open season in the spring of 1935. These carcasses were examined for sex, weight, external measurements, and condition of pregnancy. Of these, 138 were examined at the University of Michigan Museum of Zoology, 32 at the Department of Zoology, Michigan State College, and 37 at the Game Division of the Department of Conservation.

Captive beavers.—In the fall of 1929, the Zoology Department of Michigan

State College received 8 beavers from the Game Division of the Department of Conservation with which to conduct an experiment in beaver culture. Some degree of success has been attained in inducing the animals to breed in captivity, and data secured regarding breeding habits, size and sex ratios in beaver litters, and growth rates of young beavers.

Composition of beaver colonies.—The logical point at which to begin studies of beaver populations was obviously the unit of population, the colony. By "colony" I mean a group of beavers occupying a pond or stretch of stream in common, utilizing a common food supply, and maintaining a common dam or dams. They may or may not be living in the same lodge or burrows. While this definition may seem somewhat indefinite and difficult to determine, it is not so in the field. Beavers appear to maintain a system of territorial rights, and there is no evidence of overlapping of the colonies.

Estimates of beaver populations always assume some "typical" number of animals per colony as the basis for the estimate, and there has been much discrepancy as to the "typical" number that should be used. Apparently no systematic investigations had ever been carried on, the estimates being based on reports by Indians and trappers as to the number usually taken in a lodge when this was trapped out.

The data used in the following discussion of the number of beavers per colony were secured from several sources, each carefully examined as to accuracy. The largest single source of information was the reports of the nuisance beaver control operations in Michigan in 1931. Table 1 is a summary of the data obtained in this way, copied from my report published in 1933. By no means all of the colonies included in this table were used in the population studies, however, as no colonies were used unless it was certain that every member of the colony had been captured and recorded. To determine whether or not every animal had been taken, trapping was carried on until no more animals were caught for at least two days, and no evidence of beaver activity could be discerned. No repair work on the dams, no fresh cuttings for food, no tracks in the mud or sand along the bank for two days was accepted as evidence of absence of beaver. The traps were then removed, but approximately a week later, a return visit was made, and if no signs of beaver could be seen it was assumed that the colony had been entirely trapped out. If beaver sign was to be seen at that time, trapping was resumed and kept up until again no more beaver activity could be seen. In each case of this kind I have not included that colony in my tables, because there could be no certainty that a beaver had not come in from elsewhere in the interval between trapping operations. No colonies have been included in which there seemed a possibility of mistake in numbers of beaver actually living in the colony.

The colonies used were either trapped out by me, or by L. A. McIntire and A. M. Stebler, who employed exactly the same methods as I did in

carrying out and recording their operations. All reports were made on standard forms. The form and map accompanying the blanks were designed for use as data sheets for future compilations, and have proved most useful.

The figures available from the nuisance beaver work were supplemented by data gathered by me on the Gladwin Refuge and elsewhere, every colony used being subjected to the same criteria as to authenticity before being accepted.

Table 1 summarizes the work on nuisance beavers during the summer of 1931, but includes only those colonies from which we were able to obtain complete information regarding numerical composition.

Although the number of colonies and of individuals studied is insufficient to justify the drawing of definite conclusions, it appears that the number of

TABLE 1

NUMERICAL COMPOSITION OF BEAVER COLONIES

NUMBER PER COLONY	NUMBER OF COLONIES	TOTAL NUMBER ANIMALS
1	7	7
2	6	12
3	6	18
4	5	20
5	8	40
6	10	60
7	5	35
8	4	32
9	1	9
11	2	22
12	3	36
Totals.....	57	291

Total females, 50; total males, 60; total sex not determined, 181 (15 adults, 46 yearlings, 120 kits). Average number per colony, 5.1.

animals comprising a colony is decidedly irregular, and that the numerical average of 5.1 beavers per colony shown in Table 1 is of doubtful value as an index for estimating beaver populations over extensive areas. Nevertheless, since this figure is obtained by actual analysis of 57 colonies scattered over a large area of the state, it should be worth somewhat more than estimates made from one or two personal observations, or from reports of trappers and others based on haphazard trapping experiences.

Johnson (1927, p. 579) estimated beaver populations in the Adirondack Mountains on a basis of 10 animals per lodge. Morgan (1866, p. 135) stated that the trappers in the Lake Superior region estimated at the rate of 7 animals per lodge, and the trappers of the Rocky Mountain region estimated at the rate of 8 animals per lodge. Estimates of trappers and

woodsmen in Michigan are usually based on some number between 6 and 12 per lodge.

It is my opinion that the discrepancy between these estimates and the figure of 5.1 indicated in Table 1 may be explained on the basis of a common trait of human nature. Trappers tend to remember the lodges in which a goodly catch was made, and to forget those in which their catch was poor. They also very likely forget those in which only one or two animals were taken, with the thought that probably in this case they did not get all of the animals.

This idea may also explain the fact that most records of the number of animals in a beaver colony tend toward a certain uniformity. In case a colony was found to contain an apparent family group it was duly recorded, whereas if the group seemed to lack such an appearance it was not recorded but the assumption made that the entire group had not been taken.

My conclusion is, therefore, that while the figure of 5.1 beavers per colony could not be accepted as a true mathematical basis for the estimation of beaver populations over extensive areas, it is probably more nearly correct than are any of the higher average figures arrived at by casual or haphazard means. It could not, however, be used in estimating beaver population in any region in which trapping seasons are permitted.

The lodge as an index of population.—Estimates of beaver populations made by trappers and woodsmen are usually based on an average per lodge, the lodge apparently being considered as synonymous with the colony. Many beaver colonies, however, possess no lodge at all, the animals living in bank burrows entirely. This is frequently the case with beavers living in streams with high solid banks, permitting easy digging of burrows, and offering little inducement for the construction of lodges. Other colonies possess one lodge and several bank burrows, apparently each in use at the same time. Still other colonies possess two lodges in use, usually with several bank burrows in evidence as well.

Under such conditions it has never seemed to me that the lodge was a satisfactory unit upon which to base estimates of beaver populations. Consequently, I have undertaken an analysis of the available data regarding the population per lodge, dividing the colonies into those possessing no lodge; those having one lodge in use; and those having two lodges in use. I have never seen any beaver colony in which there were more than two lodges in use at one time. Occasionally one or more additional lodges may be discovered, but these have always been badly in need of repair, and were obviously no longer used by beavers. These old, run-down lodges are seldom, if ever, repaired again, the beavers seeming to prefer to build new lodges if needed.

Examination of 45 colonies indicates that the average number of beaver per colony with no lodge is 2.4, per colony with one lodge, 4.0, and per colony

with two lodges, 6.1. While, of course, these figures are not statistically significant, they do indicate the possibility that colonies using two lodges may be somewhat more populous than those using only one house. They also indicate the probable unreliability of estimates of beaver populations based on any average number of beavers per lodge observed.

Bank burrows.—I have been unable to determine whether or not certain individual animals in a beaver colony occupy the lodges and others the bank burrows, or whether the burrows and lodges are used indiscriminately by all members of the colony. Woodsmen and Indians have claimed that the male beavers are driven from the lodge before the birth of the young, and must remain outside until late summer, when the young are well grown. This sounds logical, and my own personal observations seem to be in accordance with such a view. I have never observed any evidence of antagonism between females with young and males, however, and I have observed the female and the male, in one case known to be the father of the kits, feeding and swimming together around the base of the lodge in which the young were lying at the time. Close observation did indicate, however, that the male was probably living in a bank burrow a few rods from the lodge, while the female and young occupied the lodge.

The underwater entrances to bank burrows are deep and narrow, and do not offer a suitable opportunity for the setting of live traps. Traps set *near* the entrances to burrows do not solve the problem of the actual occupants of the burrows, since beavers have a habit of swimming under water for some distance when they leave the lodge or burrow, and the beaver caught in the trap near the burrow entrance might actually have come from a lodge or burrow several rods distant.

It would probably be possible to use steel traps in determining which beavers use burrows, as these could be set in the entrance of the burrow, but this would necessitate the drowning of the animals, and I have not undertaken any measures that would result in the death of the beavers under observation.

The dam as an index to population.—There is a persistent popular notion that the number and size of beaver dams is an indication of the number of beavers in the colony making use of these dams. This idea has been contradicted by Johnson (1927, p. 578), but still persists among the general public. No evidence of correlation between the number of used dams maintained by a beaver colony and the number of animals in the colony is shown by my investigations. Such a correlation should not be expected, since the number and size of beaver dams depends on local conditions of topography, including stream flow, depth of water, availability of construction material, and distance between high banks, and little, if at all, on the number of beavers in the colony. Beavers construct dams to secure and maintain suitable water levels for their lodge entrances, and for safety and

convenience in food getting and storing, and the number and size of the dams varies accordingly.

Sex and age composition of beaver colonies.—Various estimates as to the sex and age composition of beaver colonies have been published. These are usually based on the population of the lodge as a colonial unit. My own figures are, however, based on the numbers taken per colony, and not merely per lodge.

Table 2 summarizes the data from 42 colonies studied. Only such colonies are included as were completely trapped out, and in which the sex and age were positively identified.

The numerical composition of these colonies has already been included in Table 1, so that the number of kits and yearlings is of no importance here. Sexes of kits and yearlings were not determined in all cases, but this is im-

TABLE 2

SEX AND AGE COMPOSITION OF BEAVER COLONIES

COMPOSITION	NUMBER OF COLONIES
1 female	1
1 female and kits	7
1 female and yearlings	2
2 females and kits (4)	1
1 male	6
1 male and 1 female	6
1 male, 1 female and kits	9
1 male, 1 female and yearlings	2
1 male, 1 female, yearlings and kits	8
Total	42

material in Table 2. All animals two years of age and over are included as adults in Table 2.

A typical beaver colony is shown by Table 2 to consist of an individual family, including the parents, the kits, and often the yearlings born the previous year. This corroborates the observations of the writer just mentioned. My observations of branded beavers on the Gladwin Refuge also bear out this conclusion, but indicate that the two-year-old progeny sometimes remain near the place of birth, and may live in the same pond with the rest of the family, although probably not in the same lodge or burrow. The fact that the two-year-old animals were not taken with the family group in any of the 42 colonies trapped out certainly seems to indicate that the two-year-olds are not usually members of the colonial family. Some of the single animals recorded in Table 2 may have been two years old, however. This would not affect the conclusions stated. The fact that males and females

were taken with kits in certain colonies does not prove that the males and females inhabit the same lodge with kits, as the males may have been living in burrows apart from the rest of the group, and still have been taken in the trap set on the dam. The dam, as previously stated, is the best place to take all members of a colony, whether they live in lodges or burrows.

Which beavers work on the dam?—There has been much speculation as to which beavers build and repair the dams, or at least which ones are most active in this work. Such conclusions as can be drawn from the animals studied by me indicate that males are the first to attempt repair work on broken dams, but that every member of the colony takes up the task if the male fails.

Number of young per litter.—There is no evidence that more than a single litter per year is ever produced. Small kits seen late in summer are readily explained as due to their having been born in July, at the latter end of the period during which young are produced.

My data regarding number per litter have been compiled from two sources. First, from the litters counted by me in the field, including those on the Gladwin Refuge and those taken during the nuisance beaver control work. Second, from the numbers of embryos per female taken during the spring trapping season of 1935. As stated previously, carcasses of beavers were purchased by the Department of Conservation from trappers at that time in an effort to gain information regarding sex ratios and other pertinent matters relative to a beaver-trout management program. These animals were weighed, measured, sexed, and conditions relative to pregnancy recorded at the University of Michigan Museum, at the Department of Zoology, Michigan State College, and by F. F. Tubbs of the Game Division of the State Department of Conservation.

Table 3 embodies the information secured from the animals examined during the trapping season of 1935, which covered the period March 15 to 31 in the Lower Peninsula, and April 1 to 15 in the Upper Peninsula. Since Table 3 includes data relative to sex ratios and localities as well as those relative to litter size, I have summarized the data regarding litter size in Table 4.

That the infant mortality is low in the beaver is suggested by the fact that the number of embryos per female and the number of kits per colony give practically the same figure for the average number of young per litter.

The results corroborated the reports of previous observers that 4 is the most common number of kits, and that all numbers from 1 to 8 occur. Whether or not 8 kits are born and actually survive has not been proven. I have personally observed two litters of 6 each on the Gladwin Refuge, and in each case every one of the young reached maturity.

I think it would be safe to conclude that an average of between 3 and 4

kits are produced per litter, and that in many cases these survive to become adults.

Sex ratios.—As previously pointed out, it was not found practicable to determine in the field the sex of living kits less than about 6 months of age. Hence, the majority of kits handled were not sexed. In several instances, however, I was able to follow the individuals of a particular litter through

TABLE 3

TABLE OF SEX RATIOS AND CONDITIONS OF PREGNANCY OF BEAVERS EXAMINED DURING SPRING TRAPPING SEASON, 1935

WHERE EXAMINED	PENINSULA	NO. EXAM.	MALES	FEMALES	SEX RATIO M	SEX RATIO F	NO. FEMALES PREGNANT	% PREGNANT	TOTAL EMBRY.	AVERAGE EMBRY.
Mich. State	U.P.	32	16	16	1	1	2	12%	3	1.5
Univ. Mich.	L.P.	113	55	58	.948	1	14	26%	61	4.3
	U.P.	25	13	12	1.08	1	7	58%	21	3.0
	Totals	138	68	70	.971	1	21	30%	82	3.9
Game Div.	L.P.	23	15	8	1.8	1	4	50%	18	4.5
	U.P.	14	9	5	1.8	1	1	20%	1	1.0
	Totals	37	24	13	1.8	1	5	38%	19	3.8
Grand totals	L.P.	136	70	66	1.06	1	18	27%	79	4.4
	U.P.	71	38	33	1.1	1	11	33%	25	2.3
Totals for Mich.		207	108	99	1.08	1	29	28%	104	3.7

TABLE 4

NO. OF KITS OR EMBRYOS PER LITTER	NO. OF OCCURRENCES	NO. OF KITS OR EMBRYOS PER LITTER	NO. OF OCCURRENCES
1	5	5	9
2	11	6	7
3	11	7	1
4	20	8	1

Number of litters studied, 65; number of young found, 242; average per litter, 3.72.

their first year of life, and to determine their sex as yearlings. This has yielded some positive information as to sex ratios in beaver litters. That sexes are born in approximately equal numbers is indicated by Table 5. Corroboration is also given for the conclusion that infant mortality rates among beaver are low, since in every case recorded in Table 5 I captured the animals as kits of less than two months of age, and recaptured them again as yearlings, no losses having occurred in the meantime.

A study of sex ratios among adult beavers is presented in Table 3, which includes the results obtained from sexing 207 carcasses purchased from trappers during the legal trapping season of March–April, 1935. Of these, 108 were males and 99 were females, a sex ratio of 1.08:1. This refutes the claim advanced by trappers that a heavy preponderance of males over females would be taken during a spring trapping season.

Salyer (1930) attempted to reconcile the trappers' claims of male preponderance with the approximate equality of sexes taken in 1935 by postulating a gross laxity in law enforcement during that season. According to Salyer, the state law requiring that traps be set at a distance of 50 feet or more from a lodge, burrow, or dam, was not enforced by conservation officers, which enabled trappers to catch all members of a colony indiscriminately. He inferred that had this law been enforced, a much greater proportion of males would have been taken by the trappers.

TABLE 5

SEX RATIOS IN LITTERS

NO. IN LITTER	SEX		NO. IN LITTER	SEX	
	♂	♀		♂	♀
4	2	2	2	1	1
4	3	1	4	2	2
4	2	2	4	2	2
6	2	4	4	2	2
5	3	2			
4	2	2	Totals 46	24	22

Number of litters studied, 11; number of kits found, 46; average number per litter, 4.18; sex ratio, ♂ 1.09 : ♀ 1.

I spent the entire season in the field, and my experience does not corroborate Salyer's theory. While some laxity of enforcement was apparent, it by no means reached the proportions inferred by Salyer.

The results of nuisance beaver control work in 1931 show that of the beavers examined for sex, 43 were males and 50 females, which likewise fails to bear out the theory of male preponderance at traps, as these animals were taken in spring and summer, many of them during the period of late gestation and birth of the young, exactly the time when, according to the trappers, the highest preponderance of males should occur. Even if it be true that males are often taken first in traps set on dams, trappers do not discontinue operations after the first animal is caught, and since females repair dams in every case after the male is removed, this would not result in any preponderance of males taken in traps.

The probable reason behind the trappers' theory that a large preponderance of males would be taken during a spring season seems to lie in the

prevalence among trappers of an erroneous method of sex identification. Mr. F. F. Tubbs, of the Game Division, and I carried on experiments during the 1935 season to discover whether or not trappers actually could determine sex in beavers. As the carcasses were brought to conservation headquarters for sale to the Department, we would ask the trappers to tell us which ones were males and which females. Despite the fact that these animals were skinned, exposing the external openings far better than is the case with unskinned animals, we found that females were generally identified as males. Unless the female was approaching parturition, in which case the teats are plainly evident, she would unhesitatingly be called a male by the trapping fraternity. The large castor glands, lying just above and behind the anus, were apparently taken for testes, and the lack of obvious nipples for further proof of maleness.

Had we depended upon trappers' identifications for our figures, the spring season of 1935 would have confirmed the thesis defended by Salyer, that males were taken in greater numbers than females at that time of year. Table 3, however, shows that the sexes were approximately equal. My conclusion, therefore, is that the theory of male preponderance in traps during a spring trapping season is due to erroneous methods of sex determination, and is contradicted by the evidence available.

Food.—Morgan (1868), Seton (1929), and others have attempted to list the kinds of plants used as food by beavers. A summary of these lists would be found to include nearly every plant growing within the range inhabited by the animals. Much difficulty is encountered in attempting to name the trees used as food because many trees are cut and dragged to the water to serve as material for the repair or construction of dams and lodges, as well as for food alone. It is seldom feasible to distinguish between these various usages of materials, so that trees may be included among the food plants that are really rarely, if ever, eaten. My observations indicate that beavers sample almost everything available as food, but their preferences are for a comparatively small number of trees.

The aspen group, the maples, and the willows seem to be preferred in the order given. Exceptions occur, however, which indicate some individual vagaries of taste.

I have observed a tendency toward the use of aquatic plants as food during the summer months, when tree cutting is at a minimum. Aquatic plants eaten under my observation include eelgrass (*Potamogeton*), duck potato (*Sagittaria*), duckweed (*Lemna*), water weed (*Elodea*), white water lily roots (*Nymphaea*), and yellow water lily roots (*Nymphozanthus*). I have watched beavers eagerly pulling and eating each of the above plants during summer evenings, and sometimes was unable to find that they were eating anything else at this time. Sometimes, however, the aquatic plants were supplemented by poplar bark obtained after nightfall.

The use of aquatic plants as food for beavers has been noted by the authors cited above, but I am inclined to think that the use of such plants is more extensive than has been heretofore recognized.

Very little has been published regarding the amount of food required by beavers. To secure accurate data regarding their food requirements in the wild it is necessary to know the exact number of trees cut during a definite period of time, and also exactly how many beavers were present during that time and occupied in cutting the trees and eating the food. It is rarely that these various factors can be known in the field. I have been able to secure data in which all of these factors were known on only two occasions.

In October, 1928, a pair of adult beavers was released by H. D. Ruhl on House Lake, Gladwin State Game Refuge. At that time there were no beavers on the refuge, nor in the vicinity, to the best of our knowledge. On June 12, 1929, when the beavers had been on the lake for 223 days, Mr. Ruhl counted the trees cut around House Lake, and measured the diameters of the stumps. Four kits were born on House Lake in May, 1929, but they were too small to cut trees at the time that Ruhl's count was made.

On May 29, 1930, 353 days later, I counted the stumps around the lake and measured the diameters. The 4 kits born on House Lake in May, 1929, probably began cutting trees soon after Ruhl's count, and continued to do so until after the count of 1930. Six kits were born in May, 1930, but these could not have been cutting until after the count had been completed.

The ground around House Lake was almost clear of undergrowth when the counts were made, and the work was carefully done, so I consider that the data obtained is as reliable as such data can well be under field conditions. The number of beavers present was positively known, as the result of live trapping and branding operations carried on before and after the tree counts were made.

Another tree count was made at Piper Lake, Ogemaw County. A pair of beavers migrated to Piper Lake from the Ogemaw Refuge during the first week of October, 1929. The date is known because the animals were seen crossing a road between the two points at that time.

I observed the two beavers swimming together in Piper Lake on July 5, 1930. No other beavers were living in the lake at that time, nor was there any evidence to indicate that others had been there meanwhile. The presence of other animals would not have been tolerated by the resident pair under normal conditions, and beavers were rare in Ogemaw County at that time. Hence, I feel that the assumption that this pair had occupied the lake alone during the period from October, 1929, to July, 1930 is justified.

Table 6 summarizes the data from House and Piper Lakes. The results indicate that a beaver in the wild cuts on the average .592, or approximately .6 trees per day.

Six captive adult beavers at Michigan State College consumed 180 trees

of diameters between 1 and 3 inches in one month, exactly one tree per beaver per day, or 365 trees per beaver per year. This agrees with Bailey's conclusion (1927) that "In feeding captive beavers in pens one small aspen one inch in diameter is generally found ample for one night's food supply for a full-grown adult". It should be kept in mind that captive beavers are unable to supplement their poplar diet by other foods as they can in the wild, which may account for the higher apparent consumption of poplar in captivity.

I have been unable to find any available formula for translating tree counts, with diameters of stumps, into terms of yield per acre of beaver food. Foresters use tables showing yield per acre of board feet or cord wood, but beavers eat bark and twigs, not trunks and large branches. Small trees are eaten much more completely than are large ones; trees with smooth bark are eaten more completely than those with rougher bark, even though the size may be equal.

TABLE 6

House Lake, 1929; 345 trees cut by 2 beavers in 223 days; .773 trees per beaver per day, 282 trees per beaver per year.

House Lake, 1930; 1040 trees cut by 6 beavers in 353 days; .491 trees per beaver per day, 179 trees per beaver per year.

Piper Lake, 1930; 283 trees cut by 2 beavers in 9 months; .524 trees per beaver per day, 188 trees per beaver per year.

Averaging the figures from the three counts; .592 trees per beaver per day, 216 trees per beaver per year.

In attempting to estimate the carrying capacity of an acre of poplar for beaver, many factors must be taken into consideration. Distance of the trees from water, slope of the ground, proportion of other trees in the stand, proportion of large trees to small ones, and other foods available, each influencing the number of trees needed per acre to supply a beaver colony.

For example, if the trees stand close together, many more will be lodged in falling, and so wasted from the food standpoint. Sometimes nearly one-half of the trees cut on a given acre are lodged against one another and wasted. Contrary to popular opinion, beavers are not sagacious woodcutters, and do waste much timber.

Beavers will not ordinarily cut trees more than 200 feet from the water's edge. Warren (1927) cited as unusual a tree 400 feet from the shores of Lily Lake in Rocky Mountain National Park, Colorado. Bailey (1927) said: "Beavers prefer to go only about 10 rods from shore for food, but in case of necessity they will sometimes gather food as far back as 20 or 30 rods." Orr (1935) said: "Aspen trees were cut for a distance of 2 or 3 or even 400 feet back from the edge of these small ponds, which is about the maximum distance that beavers will go to cut trees."

My own observations indicate that while the distances cited are valid, the animals may go much farther. Near House Lake, Gladwin Refuge, I found poplar trees cut and dragged to the lake from a measured distance of 650 feet. After the poplar had been cut to a distance from the shore of about 500 feet, the beavers practically ceased to cut poplar, turning their attention to scrub oaks instead. Oak trees are not ordinarily eaten by beavers, but they have furnished most of the bark eaten by the animals on House Lake for nearly 3 years. Macnamara (1929, p. 255) also mentioned the occasional use of oak as food by beavers.

The discrepancies between the number of trees cut per beaver in the two locations I explain as follows: The 2 beavers on House Lake during the period from October, 1928, to June, 1929, were adult animals, of large size, and the female bore and produced young during that period. These two adults would probably consume a maximum of food under such conditions. The 4 beavers added to the original pair for the second House Lake count were developed from kits to yearlings during the period under consideration, and were by no means as large as adults, even at the close of the period. Hence the total food consumption might well be diminished in comparison with that which would be consumed by 6 adults. The 2 beavers on Piper Lake were probably two-year-olds at the time of their arrival at the lake, and they did not produce young, a circumstance that presumably would lessen their food consumption somewhat as compared to adults producing young. Also the time of counting, July, was somewhat later, and beavers do not eat as much poplar during summer, then utilizing more aquatic plants and green herbaceous material. Hence, I conclude that the average obtained from all of the counts, 216 trees per beaver per year, represents approximately the requirements of a beaver under wild conditions better than any other available estimate.

Carrying capacity of poplar lands for beaver.—The average diameter of the trees cut by the beavers under my observation was 2.1 inches. According to Kittredge and Gevorkiantz (1929, p. 16), stands of poplar trees of about 2 inches average diameter include from 1500 to 3000 trees per acre, depending on the soil type and other factors. If we use 1500 trees per acre as a standard, and assume that one beaver will cut 216 trees per year on the average, one acre will support one beaver for about 7 years, or 7 beavers for one year.

If we use 3000 trees per acre as a standard, and assume that one beaver will cut 216 trees per year, one acre will support one beaver for about 14 years, or 14 beavers for one year. Of course these figures are only approximate at the best, as other trees and plants may also be available at the same time, and there will be some growth from sprouts to add to the supply. Thus 2 or 3 acres of poplar available to a beaver colony might easily last much more than 2 or 3 times as long as would 1 acre of equal stocking, due to the greater chance for new growth while the beavers searched less intensively for food material.

Using the figures as an approximation, however, we do have a rough means of estimating the carrying capacity of poplar lands for beaver. Since it has been shown that the average beaver colony in Michigan contains about 5 animals, it may with some degree of probability be estimated that one acre of poplar will support a colony for from 1 to 2.5 years, depending on the stand of poplar and other factors. Vague as this estimate may appear, it is certainly more dependable than other estimates have been in the past. A stand of large trees would probably be exhausted sooner, since there is usually more waste from lodging and also more waste from coarse bark uneaten. Stands of seedlings, very close together, might last longer, since they are eaten completely, and there is almost no waste due to lodging or uneaten material.

Emigration.—The experimental studies of beavers on the Gladwin State Game Refuge began with the introduction of 6 animals by H. D. Ruhl in the fall of 1928 (Ruhl and Lovejoy, 1930, p. 467). The experiment was expected to develop into an investigation of the dispersal and migration of beavers, through the marking and recapture of individual animals on the Refuge. The failure, however, of the tail tagging method of identification, which did not become evident until nearly 3 years had elapsed, and the subsequent difficulties encountered with the branding methods, delayed and partially nullified this line of investigation. The identity of many animals was lost when the tail tags dropped out, and with the uncertainty of the branding methods, and the rapid spread and increase of the colonies on the Refuge, I was unable to mark the young beavers as they appeared, so that presently I found the Refuge sprinkled with unmarked animals.

Only in the case of the colony on House Lake was I able to keep a complete and accurate record of the individual beavers from year to year. House Lake is about 10 acres in area, located close beside the Refuge keeper's lodge. It has no visible outlet, is spring fed, and is entirely unconnected with any other body of water.

An adult male and an adult female, each 3 or more years of age, were tail-tagged and released by Mr. Ruhl on House Lake, October 31, 1928. This pair produced 4 young in May, 1929, bringing the beaver population of the lake to 6 animals for that year. In May, 1930, 6 young were produced by this pair. In September, 1930, I caught every member of the colony, which included the adult pair, 4 yearlings born in 1929, and 6 kits born in 1930, or 12 animals in all.

At this time it was obvious that the tags were about to fall out of the tails of the adults, and they were branded, so that their identity would not be lost. The 4 yearlings were also branded, and their sexes recorded. The 6 kits were also branded experimentally, using much smaller irons than for the larger animals.

In September, 1931, I again caught the entire colony, which then consisted

of the 2 adults, 4 of the 6 kits born in 1930, and 6 kits born in 1931. The 4 animals born in 1929, now two years old, had disappeared from the lake, again leaving the population at 12 beavers. The brand numbers on the tails of the yearlings, branded as kits one year before, were now illegible, due to the large increase in size of the tails and of the individual scales of the tails during the year elapsed. A distortion of the tail, and a rough scar, were all that remained as proof of the previous branding. These animals were rebranded and released, the kits of the current year not being branded at this time.

Two of the 6 kits born in 1930 had also left the lake. The Refuge keeper reported having seen several sets of beaver tracks leaving the Refuge headed westward in April, 1931. How many, or which animals, left at that time we do not know. I think that these tracks were those of the two-year-olds, as I saw all 6 of the yearlings swimming on the lake at one time in July, 1931. The 2 yearlings must have left the lake between the middle of July and the second week of September.

In May, 1932, I captured the entire colony again, and found it to consist of the 2 adults, 4 female and 2 male yearlings, and a litter of very young kits, which I heard crying in their lodge. I released the female at once, and afterwards found that the litter consisted of 4 kits. Again the two-year-old animals had disappeared, and again the keeper reported tracks leading westward off the Refuge in April.

In April, 1933, I again caught the entire colony, consisting of the adult pair, and the 4 yearlings born in 1932. Once more there were no two-year-old beavers. The adult female was heavy with young at this time. Later observation showed that 6 kits were born in May, bringing the colonial population once more up to 12 animals.

In September, 1933, I caught the 2 adults from House Lake in Hoister Lake, about one-half mile east of House Lake, but separated by a brush-covered height of land. The kits born in 1933 had also accompanied the parents to Hoister Lake.

The food supply around House Lake was apparently running low at this time, all poplars having been cut to a distance of over 500 feet back from the shores, and the beavers reduced to getting most of their living from scrub oaks.

During the autumn of 1933, a pair of unbranded beavers took possession of the deserted House Lake, and produced 4 young in 1934. I did not get time to brand these beavers, but did catch them in 1935, when the colony consisted of 2 adults, 4 yearlings, and 4 kits, or 10 in all.

On December 20, 1935, the Refuge keeper caught, on the outlet to Hoister Lake, the original female beaver released on House Lake by Ruhl in 1928. Unfortunately, the beaver died in the trap. She seemed to be in excellent condition, weighed 48 pounds, and gave no evidence of decrepitude due to

age. She was at least 3 years of age in 1928 when released on House Lake, which would make her 11 or more years of age when killed. I know of no means by which the age of a beaver can be determined by inspection after the third year. Kits, yearlings, and two-year-olds are rather easily distinguished by size, and by breadth of tail, but after the third year there is apparently no criterion available for age determination. This female, with a known age of 11 years or more, offers possibly the only definite record of longevity in a wild beaver. Morgan (1868, p. 221) gave the ordinary duration of life for beavers as from 12 to 15 years. His judgment was based on reports from Indians and trappers.

Table 7 shows the sex, age, and numerical composition of the House Lake beaver colony from 1928 to 1933, and from 1933 to 1935.

The results of studies of the House Lake beaver colony indicate that the two-year-old animals leave, or are driven from, the colony shortly before

TABLE 7

SEX, AGE, AND NUMERICAL COMPOSITION OF HOUSE LAKE BEAVER COLONY, 1928–1933

DATE	ADULTS		YEARLINGS		KITS		TOTAL
	♂	♀	♂	♀	♂	♀	
October, 1928	1	1					2
September, 1929	1	1			3	1	6
September, 1930	1	1	3	1	2?	4	12
September, 1931	1	1		4	2	4	12
May, 1932	1	1	2	4	2	2	12
April, 1933	1	1	2	2	6		12
August, 1933							0

the birth of a new litter of kits. The yearlings are permitted to remain in the colony. This conclusion is corroborated by the data obtained during the nuisance beaver control work of 1931, where it was shown that no two-year-old beavers were taken by live traps from a colony containing kits. Morgan (1868, p. 135) reached the same conclusion.

I can offer some confirmatory evidence to support Morgan's statement that old beavers are hostile to their own young when these approach maturity at two years of age. It is a matter of general knowledge among beaver farmers that fighting occurs in the spring, before the birth of the young. It is also a matter of common knowledge at present that beavers fenced in an enclosure never increase beyond a certain rather definite number. My explanation of this is that the two-year-olds are attacked by the adults, and if they cannot escape by emigration they are killed. I have accordingly advised beaver farmers to live-trap all of their animals each spring as soon as the ice breaks, and to remove all two-year-olds, releasing the remainder again. In this way they could reap an annual harvest of pelts, and thereby

at least gain something, while otherwise they would reap no harvest at all (Bradt, 1934, p. 12). To the best of my knowledge no beaver farmer paid the least attention to my article or to my verbal advice, so I cannot cite evidence to prove or disprove my claims.

Some additional evidence supporting this theory may be cited from the enclosure on the Gladwin Refuge. In this enclosure a pair of adult beavers was liberated by Ruhl in 1928. Kits were produced by this pair in 1929, 1930, and 1931, as verified by observations, although the exact number of kits was unknown. In the summer of 1931 all animals were trapped out of the enclosure and only the 2 adults and 3 young kits were present. Since there is no reason to believe that any animals escaped, the missing beavers must have perished. The inference is that they were attacked by the adults, and due to the small area of the enclosure, were wounded and died.

While none of these lines of evidence is sufficient to justify a positive conclusion if considered alone, the cumulative effect is considerable, and certainly suggests that two-year-old beavers are driven from the colony by the parents in early spring before the new litter appears.

The fact that the migrating beavers struck out boldly to the west from House Lake, although there were no lakes and streams for miles in that direction, while there were lakes and streams within one-half mile to the south and east, indicates that beavers, like muskrats, do not hesitate to travel overland in spring. Whether or not the westward overland trek signifies an instinct to travel west, or merely an accidental occurrence, I cannot guess. Little Trout Lake lying just south of House Lake was occupied by other beavers during the history of House Lake occupancy, as recounted, but Hoister Lake to the east was not. Yet Hoister Lake remained untenanted by beavers until its invasion by the adults from House Lake in 1933. Consequently, I do not believe that any conclusion can be drawn from the evidence at hand regarding the reasons for the direction taken by migrating beavers, other than that they may not do the logical thing from a human viewpoint.

Importance to the beaver of emigration.—I have shown that the beaver colony is a family unit, composed of a pair of adult parents, the yearlings, and the kits.

The forced emigration of the two-year-old animals in the spring, just before the young are born, has a profound influence on the ecology and distribution of the beaver. As a consequence of this emigration, the beaver colony is limited to 14 or less animals, since litters of more than 6 young are rare, and the presence of two successive litters of 6 each, plus the adult pair, would be necessary to bring the total number per colony to 14. Actually the total number per colony rarely exceeds 12.

The limitation of the colonial inhabitants to 14 or less prolongs the period of occupancy for each site, as the addition of other mature beavers would materially increase the rate of tree cutting for food, and would exhaust the accessible food supply more rapidly.

The emigration of the vigorous young animals provides a method for the systematic dispersal of beavers, because the animals are obliged to seek new home sites, and since the members of a colony resent encroachments into their territory by strange animals, the new homes must be established in places not already stocked by beavers.

I have been unable to determine whether the two-year-old emigrants seek new mates, or whether brother and sister mating takes place. If new mates are secured, the emigration would result in outbreeding, with a possible increase in vigor, and a lessened tendency for hereditary defects. In regions with an extensive beaver population, it seems probable that emigration results in outbreeding, as wandering males and females would be likely to encounter others of the opposite sex. Beavers produce young in the spring of their third year of life, so that the wandering two-year-olds would have all summer and early fall during which to select new mates. In regions where beavers are scarce, the chances of meeting other animals would be lessened, and brother and sister mating might result.

It may be conjectured that the development of the beaver colony as a unit of population has been due to a continuation of simple family life. The young are accepted as members of the family because of the bond between mother and offspring. The yearlings, still sexually immature, and of relatively small size, are tolerated as a matter of course. The two-year-olds, almost as large as the parents, and possibly showing signs of sexual maturity, are objects of jealousy and are consequently attacked and driven from the family territory.

SUMMARY

The present study is an attempt to secure more adequate data regarding beaver populations and beaver ecology in Michigan. Methods of live trapping, branding, and determining sex of beavers have been developed.

The number of beavers per colony is irregular, varying from 1 to 12 animals. The numerical average of beavers per colony for the 57 colonies studied intensively was 5.1.

The number of beavers per lodge is not a satisfactory unit for use in estimating beaver populations over extended areas.

The number and size of beaver dams afford little indication of the number of beavers present.

The "typical" beaver colony consists of an individual family, including the two parents, the yearlings born the previous year, and the kits of the current year.

Every member of a beaver colony aids in maintaining the colonial dams.

The average number of beavers born per litter is between 3 and 4. There is only one litter per year.

The two sexes are approximately equal in number in the beaver, the number of males slightly exceeding the number of females.

The beavers studied cut between 200 and 300 trees each per year.

One acre of poplar (aspen) should support an average beaver colony from 1 to 2.5 years, depending on circumstances.

Yearlings are permitted to remain in the colony, but the two-year-old beavers leave or are driven from the home colony shortly before the birth of the second annual litter.

Beavers do not always follow water courses during emigration, but may undertake long overland journeys.

The emigration of the two-year-old beavers provides a method of dispersal, and tends to establish new colonies in areas not previously stocked with beaver.

The size and composition of beaver colonies is such as to permit the efficient and economical use of food supplies adjacent to small bodies of water.

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LIFE HISTORY NOTES ON THE NORTHERN PINE MOUSE

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Because of their abundance, wide range and tremendous economic significance to the orchardist, one might suspect pine mice to have been the object of much study. Such does not seem to have been the case. Observations that I have made on the northern pine mouse, *Pitymys pinetorum scalopsoides*, during the past few years are here placed on record. When the gaps in our knowledge of the habits of this mouse are made apparent, it may arouse a wish to make further studies on this little-known but important rodent.

Measurements, weights and molts.—Pine mice are sleek, large-headed, short-tailed rodents well endowed for a subterranean existence. The small eyes, less than 2 mm. in diameter, hidden ears, and silken fur, together with the serpentine manner that they employ in running through the maze of burrows, are indicative of fossorial habits. The flesh-colored nose and feet, dark facial mask, and bright chestnut back are good field characters.

A rather well defined molt, more marked than in *Microtus*, occurs biannually. The darker pelage of winter is replaced during May or June by the light chestnut dorsal pattern of summer. In captives the molt starts on the head and proceeds caudally to the shoulders (fig. c). At the same time the old fur of the venter is being replaced by new. The rump and haunches are usually the last to be clothed by new fur. Fall molting is noticeable in November, and less often in December-caught specimens. The molt is completed in 3 weeks. Young mice wear their dark juvenal coat until 5 weeks old, the adult chestnut pelage first appearing on the sides of the animal. The complete adult coloration is attained at 7 weeks.

Average measurements of 15 adult New York pine mice are: Total length, 126 mm.; tail, 19; hind foot, 18. The largest mouse, an adult male, weighed 35 grams, the usual weight of adult mice being 25–30 grams.

Burrows and nests.—In digging about the forest floor, the pine mouse threads its way just beneath the thick carpet of leaves, the latter forming a thin but substantial ceiling to the burrow. The mouse may rarely tunnel to a depth of a foot or more, but by far the greater number of subterranean trails that I have uncovered are shallow, descending to a usual depth of 3 or 4 inches at most. The burrows vary in diameter with the type of soil and permanency. They may be 1.5 to 2 inches in diameter, but the usual bore is somewhat less than this. In the orchard these tunnels thread their way to fallen apples, where the mice burrow from beneath to feed on the fruit. I have lifted the hollow shell of a Greening, only to find a plunge-hole leading to the horizontal tunnel a foot beneath the surface. The mice, alert for enemies, seldom leave their subterranean runways, yet Morris M. Green

writes me that he has trapped them above ground. I have likewise taken these mice in shallow, exposed runways.

In the construction of burrows the mouse employs its fore-feet and stout incisors to loosen the earth and rootlets. The heavy head and neck are particularly useful in burrowing. When a bit of dirt is loosened it is thrown back by the hind limbs. I once liberated a large male in a spacious enclosure containing several bushels of loam, moderately packed by rain. The mouse tunneled from view in 40 seconds.

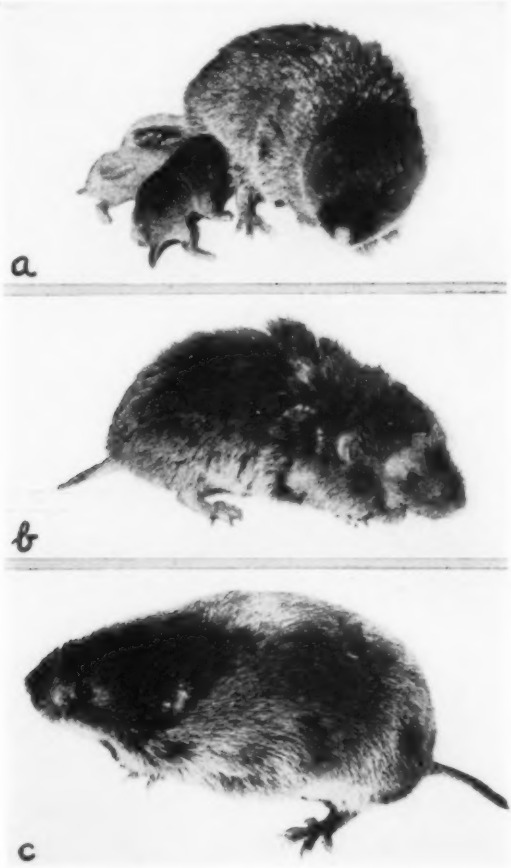
The nests, globular in shape, are constructed of the most available material. Dead leaves and grasses, occasionally green, are used in their construction. The nest may be just below the ground surface; less often it is under some shallow-rooted stump. While blasting mouse-girdled trees from an orchard at Croton Falls, New York, Clinton Haight found a number of these nests under the dead apple trees. Three or 4 exits usually lead from the nest.

Pine mice utilize the runways of moles, and, where these mice occur in wooded districts, they are taken from tunnels in the black loose leaf mold frequented by *Parascalops*, *Peromyscus*, *Blarina*, *Clethrionomys*, and *Sorex*.

Habitat.—Few small eastern mammals exhibit such diverse habitat selection as the pine mouse. Its very name is a misnomer, for, although the type of *Pitymys pinetorum* was taken in the pine woods of Georgia, the northern race is usually a creature of the deciduous woods. In Indiana, according to Hahn (1908), it lives in the rocky hills, about the caves, in the heavy woods where the carpet of dead leaves is several inches thick, and in the fields. Copeland (1912) took 6 specimens of a small colony on the very summit of Mt. Greylock, Massachusetts, at 3505 feet elevation. They were trapped beneath the spreading roots of the rather open growth of spruce and yellow birch, in the midst of a Canadian environment. Saunders (1932) found them abundant in dry beech woods and in moist banks of a wooded ravine in Middlesex County, Ontario. Poole (1932) found them most abundant in light sandy alluvial soils supporting a scattered growth of trees and shrubs, and large numbers resort to the apparently inhospitable muck and culm of the coal region of the lower Schuylkill Valley of Pennsylvania. Poole has also found a colony on the north slope of the Kittatiny ridge in Pennsylvania at 700 feet elevation, neighbors to *Clethrionomys* and *Sorex fumeus*. I have collected this mouse in the virgin hemlock stands of the Tionesta Forest of Pennsylvania, have noted its numerous tunnels in the sandy soils of Long Island, a few feet above sea level, trapped it in the maple-beech association at Ithaca, New York, and once caught an individual in a sphagnum swamp choked with winter berry (*Ilex verticillata*). To find *Pitymys* in wet ground was a real surprise, for most writers have emphatically stated that the pine mouse avoids swamp lands.

In the lower Hudson Valley of New York the mice are locally abundant, but appear to colonize here as elsewhere. I recall one large orchard at

Croton Falls, New York, where the mice were unusually abundant. A neighboring farm had apparently never been visited by the mice, yet both have the same soil, a fine sandy Cossayuna loam.



a. A nursing pine mouse with young five days old. *b*. A diseased pine mouse from the Hudson Valley of New York during the spring of 1936, with glabrous areas on head and shoulders. *c*. A molting pine mouse.

Food.—The pine mouse, due in a measure to its subterranean habits, feeds largely upon succulent roots and tubers. Specifically, Audubon and Bachman (1851) mentioned peanuts, the seeds of grama grass, and *Tripsacum*

dactyloides; Quick and Butler (1885) listed young sprouts of the white clover, *Trifolium repens,* fruit of the red haw, *Crataegus coccinea,* and the tuberous roots of the wild violet, *Viola cucullata.* These writers found stores of fruits and rootstocks, some containing a gallon of tubers, at depths 18 inches below the ground surface. These caches supposedly form the bulk of their winter food. Kennicott (1857) found the bark gnawed from the roots of briers, and credited the pine mouse with storing hickory-nuts, hazel-nuts, and acorns of burr and white oaks. The tubers of Dutchman's breeches were listed by Schmidt (1931) as a favorite item of food. Saunders (1932) recorded the related squirrel corn as a food utilized. About 4 inches underground, in a pocket scooped out of clay, he found a half pint of the roots of squirrel corn. None of these roots had budded, and although they had evidently been gathered the previous fall, they were very fresh. Stomach contents of *Pitymys pinetorum auricularis* from Indiana examined by Hahn (1908) yielded seeds and roots, and insect remains in two.

During late June, 1932, I uncovered considerable stores of the tuberous rootstocks of wild morning glory, *Convolvulus sepium,* in shallow burrows of the pine mouse in Dutchess County, New York. Similar observations were made in the lower Hudson Valley at Croton Falls, New York, during August, 1936. At times the rootstalks, cut into match-sized lengths, effectively plugged the bore of the tunnel. A handful of the succulent white new roots of quack grass, *Agropyron repens,* were removed from a pocket of a shaft about 6 inches below the surface. The mice were also feeding on the fleshy yellow rootstocks of broad-leaved dock, *Rumex obtusifolius,* by biting the stem cleanly off at the ground level, then eating the root to a depth of several inches. By removing the thin roof of shallow burrows, a great number of the plant remains carried underground by pine mice could be determined. In orchards were these mice occurred I found in the burrows the stems of barnyard grass (*Echinochloa crusgalli*), witch grass (*Panicum* sp.), sandbur (*Cenchrus pauciflorus*), the stems of *Polygonum,* and the leaves of *Ranunculus.* Captive mice relish meat and insects.

Due to its subterranean habits, the pine mouse, when feeding, rarely sits upright like *Microtus.* The food is held in the fore-paws, pressed against the ground or floor of the burrow, and the mouse thus feeds in leisurely fashion.

The agriculturist is concerned chiefly with its depredations in the orchard. There the apple trees, chiefly those 6 inches or less in diameter, are frequently girdled so severely that bridge-grafting is impossible. I have seen uprooted trees wholly girdled, the smaller pencil-sized rootlets completely eaten or cut from the tree. It is small wonder that efforts have been made to prevent its ravages, frequently unrecognized until the tree is past recovery.

Reproduction.—Inasmuch as *Pitymys* is a cyclic species, its reproductive behavior undoubtedly varies from year to year, depending on the status of the population, as has been demonstrated for *Microtus* (Hamilton, 1937).

Captive mice bred from early April to late September. Clinton Haight of Croton Falls, New York, found young mice attached to the teats of their mother in late March, 1936. Rhoads (1903) remarked on the fecundity and stated: "I have taken nursing and gravid females of this species, as with other of the native mice, irrespective of season [in New Jersey and Pennsylvania]. They probably have 4 to 6 broods yearly averaging 20 to 30 young per annum."

Audubon and Bachman (1851) credited the pine mice with 3 or 4 litters annually, these restricted to the spring and summer months. One confined by them produced 3 litters of 3, 7, and 4 respectively. Bachman reported that he had seen 9 young taken from one nest, but it seems highly probable that this was a litter of *Microtus*. Of 4 gravid *Pitymys nemoralis* examined by Linsdale (1928), 3 mice contained 2 embryos while one carried 3. Three suckling young were clinging to another female. Saunders (1932) recorded a nest containing 2 young. Helme (1902) and Rowley (1902) credited this species with never having more than 2 to 4 young. Dr. W. H. Burt (personal letter) has trapped pregnant pine mice in southern Michigan in late October, and recorded a female with 2 embryos. Earl Poole collected juvenile pine mice in Pennsylvania in February, 1931, which suggests winter reproduction. Robert Eadie found but 2 embryos in gravid pine mice collected at Durham, New Hampshire.

My observations suggest small litters, the usual number being 2 to 4. Of 14 litters in captivity, 4 of them contained 2 young, 9 had 3, and 1 had 4 young. The few records of wild nest young substantiate the premise of small litters, never more than 4 having been taken from a nest.

Description of the young is based on captive-born mice, the measurements and weights being the average of 20 of similar age.

Birth.—In appearance almost exactly like *Microtus*, although the back is not so markedly flesh-colored as in young field mice, being somewhat duller and foreshadowing the appearance of the first hair. Weights, 2.2 gms.

Three days.—All of dorsum lead colored; underparts, flesh color. Total length 46 mm., tail 4, hind foot 6, weight 3.7 gms.

Seven days.—Head and back well covered with fine sleek lead-colored fur. Size: 55 x 5 x 8; weight, 5 gms.

Nine days.—Belly well furred. The young crawl about vigorously. Relatively silent, in sharp contrast to the noisy young of *Microtus* at the same age. Eyes opening. Weight, 6.7 gms.

Twelve days.—Very active. In a few litters the young have not opened their eyes. Size: 74 x 9 x 12. Weight, 7.0 gms.

Sixteen days.—A few still nursing at this age. Weights 10–11 grams. Commencing to eat solid food; all weaned on seventeenth day.

Twenty-four days.—Young mice are very active, well furred in the soft downy juvenal coat which shows no chestnut. The first hint of the latter color appeared on the twenty-sixth day. Weight, 15 grams.

After this period, the young grow about 2 grams per week until the mature weight of 25–30 grams is attained.

Perhaps the most remarkable habit of young pine mice is the amazing tenacity with which they grasp the teats of the mother. Most nest young of murine species exhibit this trait, but in no species have I seen it so well marked as this. A nursing *Peromyscus*, frightened from her nest, will drag off the youngsters without ceremony, but it is usual for one or more to be lost during the precipitous flight. So also with *Rattus*. But a young *Pitymys* has no intention of releasing its meal ticket, and clings so tightly that it is a real effort to loosen one. One can lift the nursing young into the air, suspending the squirming parent for minutes, yet the young grasp the teats with even greater tenacity. It is only with much effort and coaxing that the youngsters are finally freed. The young mice, if removed from the parent, nuzzle one another and will grasp the flanks of a sister or brother in an apparent effort to nurse. Clinton Haight of Croton Falls, New York, has frequently seen in his orchard the parent mouse dart off with young securely attached, and remarked on the empty nests which greeted his exploring spade.

The reason for this extreme degree of attachment is not known, but advantages are quite apparent. In low ground, during a spring freshet, or if pursued by a bloodthirsty *Blarina* or hungry snake, immediate flight would possibly guarantee the safety of both mother and her brood.

Four inguinal and post-abdominal mammae are present. Only those necessary to accomodate the number of young, if they be less than 4, are used.

The gestation period has not been determined, although in all probability it approximates the 21 day period of *Microtus*.

Numbers.—Like other cyclic rodents, the pine mouse population varies from year to year. In suitable areas, where they find agreeable living conditions, their numbers approach optimum densities with regularity, and apparently coincide, at least in New York, with the *Microtus* cycle. In the winter of 1931–1932, both species, but notably *Pitymys*, did considerable damage in the lower Hudson Valley, and were reported by orchardists as unusually abundant. I visited the area during the summer of 1932, and while old signs were everywhere, dying trees most evident, and other signs of recent abundance pronounced, there was little indication of their actual presence. No fresh underground tunnels nor surface trails were evident, nor did the few old burrows that I opened harbor the characteristic dung and fresh cuttings. The pine mice did not, of course, totally disappear. Those remaining were not long in replenishing their tribe and by the spring of 1935, and notably the following winter, their numbers once more had threatened the orchards. In one orchard at Croton Falls, New York, I estimated the population as between 200 and 300 mice per acre. These were principally *Pitymys*, few field mice occurring in the particular orchard that I investigated.

Mice were still numerous in the fall of 1936, but their numbers had materially decreased. Wharton Huber informed me that a similar situation prevailed in northern Chester County, Pennsylvania. *Pitymys* were numerous in 1934, very abundant in 1935 and the early spring of 1936, but very scarce indeed in the summer and fall of 1936. Huber recalled that field mice had their years of increase, and sudden decrease in years that coincided with the rise and fall of *Pitymys*.

There is evidence that increase is not so spectacular in habitats where the mice are not customarily found in numbers. In central New York a few may be taken in the maple-beech woods at almost any season, but their numbers appear to be more or less constant.

Enemies, parasites and diseases.—Pitymys are not as susceptible to predators as other small mammals; this is reflected in their small litters. An examination of owl pellets from the towers of the Smithsonian Institution at Washington by Fisher (1908) indicates the relative infrequency of their capture by owls, for of 3800 microtine remains, but 19 per cent were of this species. Poole (1932) captured a large blacksnake that had succeeded in forcing half its length into a pine mouse burrow.

Pine mice have their share of ectoparasites. During the early spring of 1936, when their numbers in parts of the lower Hudson Valley of New York were unusually high, I examined several dozen that were heavily infected with mites, ticks, fleas, and especially lice. The most abundant mite, *Laelaps microti* (Ewing) occasionally numbered close to 1000 per mouse. A number of undetermined Parasitoidea were collected. Lice, *Hoplopleura*, of two apparently undescribed species, were so abundant at this time that every one of the longer hairs appeared to support an individual. The louse nits on the vibrissae, facial hairs and rump literally numbered in the thousands. A few fleas, *Ceratophyllus* sp., have been recovered from trapped mice. These fleas sometimes persist on the animal for 20 hours or more after death.

It is rather well established that microtine populations, after attaining excessive numbers, are drastically reduced by murine diseases. This was most evident in the spring of 1936, coincident with an epizootic among *Microtus*. Pine mice collected at Croton Falls, New York, and received in the laboratory at Ithaca, were suffering from a skin malady, causing great patches of fur and epidermis to slough away, leaving large glabrous patches on the head, shoulders and flanks (fig. b). This condition was attended by slight pustular excrescences, accompanied by redness and a general eczematous condition. Several weeks after the onset of these symptoms, a hard dry crust commenced to form about the eyes, eventually drawing the lids together and causing blindness. General weakness of the hind quarters accompanied these latter symptoms, eventually developing into complete paralysis and eventual death.

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THE DERMAL GLANDS OF SHREWS

By W. Robert Eadie

Both the sudoriferous and sebaceous glands of higher vertebrates are often modified to perform special functions in certain regions of the body. In many mammals, including the Soricidae, such glands produce specific odors that serve some function in the life habits of the animal by giving off a distinctive scent, although the actual part that the odor plays is frequently difficult to determine.

Dermal Glands in Blarina.—Blarina brevicauda, the short-tailed shrew, produces an odor that is sufficiently repulsive to prevent certain carnivorous mammals from feeding upon it when other food is available. This odor is attributed, in the literature on the subject, to glands located on the sides of the body. Sigurd Johnsen has investigated these flank glands in several species of European shrews. Like most shrews, the short-tailed shrew has a gland located on each side of the body at the level of the axilla and halfway between the fore and hind limbs. In addition, a large median ventral gland is present, to which little reference can be found in literature. Coues (1896), however, described the location and external appearance of this gland, and Hamilton (1929) mentioned a peculiar looking bare spot on the ventral abdominal region of this shrew.

The side glands of the short-tailed shrew are not always readily visible externally. When the skin is removed, however, the glandular regions show on the inner skin surface as reddish areas, because of the vascularity of the regions. These glands are oval in shape, measuring about 4 mm. wide by 8 mm. long. In sections the side gland is seen to be composed of a mass of large sweat glands lying in the deeper part of the corium of the skin, and of large sebaceous glands above the sweat glands in the upper portion of the corium (Fig. 1). The glands are richly supplied with blood vessels, which ramify in close contact with the glandular walls. These sebaceous glands show but little difference in their structure from normal sebaceous glands. They are larger and have a fuller outline, but that is the only difference apparent to the eye. The sweat glands are large and closely massed, and constitute fully half the bulk of the gland.

These side glands of *Blarina* show a definite variation with the reproductive cycle, at least in the male. The gland elements show an apparent increased activity concurrent with the growth of the testes during the breeding period. Johnsen, in his previously mentioned paper, found that the preparatory stages of secretion in the sweat gland elements take place with the enlargement of the testes. In the short-tailed shrew there is evidence of secretion by the sweat gland elements when the testes are in the resting stage, as verified by histological section of the testes. An enlargement of the testes was found in the early spring and again in the early fall, during September and October.

This observation concurs with that of Hamilton, who noted an external enlargement of the side glands of the male with the enlargement of the testes.

In the female, no marked variation of the side glands, smaller than those of the male, was observed with the reproductive cycle.

The question naturally arises as to what function these glands may serve in the life of the shrew. The noticeable variations of the side glands in the male in correlation with the reproductive cycle leads to the assumption that they play a part in the sex life of the animal. Such, indeed, was the opinion of Hamilton, who stated that when the male and female are placed together, the hair about the area of the side gland in the male is parted to make a bare-appearing patch. He suggested that perhaps the shrews, in rubbing against the sides of the burrows, leave a scent to attract one another.

The ventral gland of *Blarina* is situated in an oval area of the skin on the abdomen, measuring about 10 mm. wide by 15 mm. long, and is at the

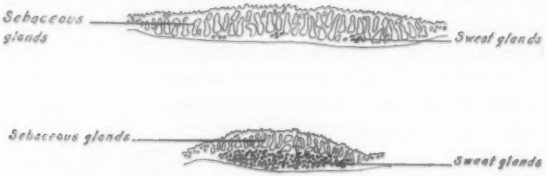

FIG. 1. Upper detail; diagram of cross section through the ventral gland of *Blarina brevicauda*. Lower detail; diagram of cross section through the side gland of *Blarina brevicauda*. Both X 5.

midventral line about 2.5 cm. anterior to the inguinal region. This area is marked by the absence of the long body hairs in a region about 5 mm. wide by 10 mm. long, where the gland discharges its secretion. When a specimen is freshly skinned, the bases of the gland elements show, under a hand lens, through the inner skin surface, as round white bodies. Large blood vessels supply this area and branch to form a dense plexus about the base of the glands.

The ventral gland is composed of enormously enlarged sebaceous elements that extend the entire depth of the skin and rest upon a thin layer of connective tissue and muscle (fig. 1). The skin itself is much thicker here than elsewhere. The greatly enlarged sebaceous elements show all the characteristics of common sebaceous glands in their structure, being simple or branched tubular glands, and pour their secretions into the upper part of the hair follicles. The elaboration of the secretion of the sebaceous elements is much the same as in common sebaceous glands.

The sweat glands of this ventral glandular region are few in number and are displaced to the deepest part of the corium by the enlarged sebaceous elements. There is no reason to believe that the sweat glands here play

any part in the formation of the secretion of the ventral gland, since there is no noticeable variation in structure from those of other regions of the skin; and the sebaceous elements, therefore, are probably responsible for the characteristic secretion of the ventral gland. In contrast, the sweat glands of the side glands evidently play a very important part in the formation of its secretion.

In a histological study of the ventral gland with reference to the sexual activity of the animal throughout the year, very little variation was found in the male. The sebaceous elements of the glands grew slightly larger, concurrent with an increase in the size of the testes of the animal, but these same sebaceous elements are in a condition of active secretion throughout the year.

The ventral gland of the female is slightly smaller than that of the male and shows one important variation in its activity. In the pregnant female, the ventral gland shows a marked decrease in function. The sebaceous elements are small in size and their outlines somewhat irregular in appearance, the alveoli not being distended by actively secreting cells. The skin of this ventral glandular area has diminished in thickness and is only half as thick as normal.

The constant functioning of the ventral gland throughout the year in the male and, with the exception of the period of pregnancy, in the female, leads to the assumption that the ventral gland is not an organ associated primarily with the sex life of the animal. In addition, the different structure of the ventral gland as compared with the side gland would point to a possible difference in function. It is known that many animals will not eat *Blarina brevicauda* because of its extremely strong and repulsive odor. Cats have been known to kill this species of shrew but never, apparently, to eat it, although it is eaten by owls and weasels. In a freshly trapped specimen, the secretion of the ventral gland may be obtained by applying a finger to the ventral gland area. It is found to have the strong repulsive odor so characteristic of *Blarina*. Consequently, one may ascribe a protective function to the ventral gland. The secretion is unctuous and resembles an ordinary sebaceous secretion in that respect. In addition it must have certain volatile constituents that give it the powerful odor.

The ventral glandular region is very strongly and closely attached to the underlying abdominal muscles, while elsewhere on the body the skin is comparatively loose. A strong contraction of the abdominal muscles would exert considerable pressure on the sebaceous elements of the ventral gland, expelling their secretion. Thus, when frightened or enraged, the shrew might voluntarily expel its protective secretion.

A study of the normal dermal glands of *Blarina brevicauda* shows that on the entire body surface, in association with each hair follicle, there may be found a normal sebaceous gland that provides lubrication and protection for the skin and hair. The sweat glands were found to vary somewhat in

size and distribution. In the abdominal and thoracic regions, the sweat glands occupy a position in the middle of the corium just beneath the layer of sebaceous glands. They are relatively large in this region and are evenly distributed. From the ventral to the dorsal surface of the animal, the sweat glands decrease in size and become scattered, so that in the skin of the dorsal surface the sweat glands are relatively small and thinly distributed.

Dermal Glands in the Genus Sorex.—Observations on the structure of the side glands in the genus *Sorex*, substantiated in general those of Sigurd Johnsen on European species. In *Sorex vagrans vagrans*, sections of the skin from various regions showed that normal sebaceous glands are found in association with each hair follicle on the entire body surface. Normal sweat glands were present in the skin of the ventral surface, but were very small in size and few in number. In the skin of the dorsal surface, the sweat glands were either very scarce or entirely lacking, as none were found in the sections studied. Sections of the side glands were very similar to those of *Blarina*, but presented one structural peculiarity not present in the latter. The hair follicles over the glandular elevation slant to the center, so that the hairs are thus opposed to one another on the gland surface, forming a peculiar cone-shaped mass.

The general distribution of the dermal glands in *Sorex fumeus fumeus* was the same as that in the preceding species. Side glands were present and were very prominent, appearing as definite areas on the outer skin surface. The long body hairs were parted about an area measuring 9 by 5 mm. This area was delimited by a circular ridge of raised skin surrounding a shallow pit from which a thick growth of short body hairs extended. The histological structure of the gland in this shrew corresponds in its general plan to the side glands of *Blarina* and of *Sorex vagrans*. The circular ridge of tissue, so noticeable on the skin surface, is caused by a local accumulation of sweat gland elements to form a layer twice as deep as in the center of the glandular area.

Examination of the dermal glands of *Sorex trowbridgii humboldtensis* showed them to be of essentially the same character as those noted above.

The function of the side glands in the above species of *Sorex* is, in all probability, closely correlated with the reproductive cycle, although there are at hand no data on this point.

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FURTHER OBSERVATIONS ON THE PHYSIOLOGY OF THE ELEPHANT

By Francis G. Benedict and Robert C. Lee

Following a survey of the physiology of the elephant reported in 1936 (Benedict), sustained interest in this physiologically important animal led to further observations, particularly to fill obvious lacunae in the first study. Measurements of the gaseous metabolism were not possible, for the respiration chamber constructed especially for this huge animal had been dismantled, but by contacts with the several circuses touring the country, especially during the longer sojourns of the Ringling Brothers Circus under cover at New York and Boston, a number of pertinent observations worthy of record were made. In the securing of these supplementary observations we were fortunate in having the cooperation of Mr. R. J. Fraser, and particularly of the head elephant man, Captain Lawrence Davis, and his associates. The rapport between the elephant men and their animals made many of the observations possible.

Muscular activity.—Because of the enormous mass of these great creatures, an exaggerated importance is usually attached to their muscular activity. The swaying motion of a 3 or 4 ton elephant from side to side, the continual movement of the trunk, and the frequent ear movements instantly challenge attention. Rarely, however, are the relative sizes of the parts of the body moved taken into consideration. If an elephant could be placed within a huge glass cage and, by means of a reducing glass, the ensemble be made to appear to have the size of a half-pint fruit jar containing an elephant the size of a mouse, the elephant would seem extraordinarily tranquil when compared with a normally quiet mouse. The earlier analysis of the body movements of the elephant showed that in general they consist of movements of the lighter-weight portions of the body, that is, the tail, the trunk (especially the lower end), and the ears. The latter, although enormous, represent a relatively small proportion of the total body weight. The heat production of the elephant was found to be very high, and as it was impossible to measure the heat production under conditions of complete repose, the problem arose as to what proportion of this metabolism was ascribable to its incessant movements. It was concluded that only when the animal is moving its huge body from side to side in the characteristic motion called "weaving" can the muscular activity be sufficient to have a measurable effect in increasing the metabolism. The inability of the elephant to make major lateral head movements necessitates its moving the entire body when it wishes to look to the rear. In general, however, the movements when the animal is not weaving are confined to the seemingly incessant movements of the ears, the tail, and the trunk.

Rhythm of movements.—In the major muscular movement of weaving, the elephant usually sways from side to side, shifting the weight from one foot

to the other, and less often moves forward and back, shifting the weight from the front legs to the rear legs and the reverse. At night, when the animals are not excited by the presence of onlookers or by other stimuli incidental to circus life, it was frequently observed that these weaving motions have an extraordinarily uniform tempo. At the New York Garden, between 1 and 4 A.M., many of the Ringling herd were noted to move from side to side at a tempo of about ten movements in 28 or 29 seconds. The forward and back motion, although less common, likewise has a uniform rhythm. One elephant was exceptional in that the time for 10 movements was nearer 16 rather than 28 seconds. The building was quiet save for the occasional roaring of lions or the barking of sealions. Only two attendants, night watchmen, were on duty. They moved about quietly, sometimes commanding one of the elephants to assume the place in line from which it had strayed. No external stimulus could be associated with the observed tempo, and we were convinced that the rhythmic nature of the elephant's motions is a clearly established fact.

Tail movements.—In June 1937, while watching the Ringling herd at Bangor, Maine, the observer stationed himself so that he could notice the tails of nine or ten elephants. The tails were in constant motion. At no time was any one tail quiet for a full 5 seconds. This was not due to the presence of flies. A few small flies were gathered around the boluses of feces on the ground, but there were none on the rump, the back, or the legs of any of the elephants. The tail was, therefore, not kept in motion to remove flies. Frequently a fairly regular tempo in the tail movements was noted, comparable to the swing of a metronome. It happened once that the tail movements of one of the elephants (Hattie) was in exact time with the tempo of the circus band playing in a large exhibition tent nearby, and the first thought was that the tail movements were synchronized with the band. The time required for 20 complete pendulum motions of the tail, as noted on a stopwatch, was close to $32\frac{3}{5}$ seconds. A typical series of such counts with this elephant showed that the times for 20 complete swings of the tail were, successively, $32\frac{2}{5}$, $32\frac{2}{5}$, $32\frac{2}{5}$, $32\frac{1}{5}$, $31\frac{4}{5}$, $31\frac{4}{5}$, $32\frac{2}{5}$, $32\frac{3}{5}$, and $32\frac{1}{5}$ seconds. There was no interruption in the tail movements of this particular animal, and it was soon found that this periodicity continued not for minutes but from quarter-hour to quarter-hour, the observations extending over nearly two hours. During this time the tempo of the band in the tent changed frequently; but there was no corresponding change in the tempo of the tail movements. The elephant's tail might properly be described as an animated metronome. One remarkable feature of the regularity of the tail movements of Hattie was that the happenings around her seemed to have no effect upon her. At one time the men were dragging around galvanized iron washtubs full of water for the various animals to drink. The elephants were anxious to reach the water tubs, stretching out their trunks and straining on their

chains. Hattie herself made this exertion but without the slightest interruption in the regularity of tail movement. At another time the men brought several bales of hay, and again the elephants were searching and reaching for it. The animal next to Hattie reached over to get more than her share, and there was a slight quarrel, but during this time the tail movements did not cease in regularity. A bag of bread, which is much relished by elephants, was broken open at one time, with no disturbance of the rhythm and yet with great eagerness on the part of Hattie to get her share. An elephant beside this animal was considerably annoyed by one of the men who was playing a mouth organ and exhibited a great deal of irritability, but this also had no effect upon the tempo of Hattie's tail swing. Another animal nearby (Clara) likewise showed a uniformity in tail movements, the time for 20 complete swings being about 32 seconds. When the measurements on Clara were made, the band was not playing. However, Clara rarely swung her tail continuously for more than 15 or 20 movements. Then the rhythm was temporarily interrupted by a short body movement or a shifting in body position. Also with Clara there were periods of a few seconds with no tail movements.

Ear movements.—One of the commonest beliefs is that the elephant uses the ears as a heat-radiating surface, which can be increased at will by raising the ears from the body. It is also believed that the ears are used as huge fans, to aid in heat loss. The elephant has the largest heat production per unit of surface area (approximately 2000 calories per square meter per 24 hours) of any animal whose metabolism has been measured. On the other hand, the elephant is essentially a hairless animal, with no protection against heat loss other than its thick skin. It seems improbable, therefore, that the ears can play any considerable rôle in heat loss. Some of the early observations of the Nutrition Laboratory contributed to this belief, however, particularly the measurements made in 1921 (Benedict, Fox, and Baker, 1921a, 1921b) of the temperatures of the surface of the ears of two elephants at the New York Zoological Park. During the course of these measurements some extraordinarily high temperatures were noted at the extreme tip of the ear. This suggested that the ear is highly vascular and hence might be used for increasing heat radiation. When elephants have been working hard, their ears feel warm to the hand. There is an essential difference, however, between a richer blood supply to the ear and ear movements. Throughout the entire survey, both in the earlier and in the present series, particular effort was made to note whether there is any possible relationship between ear movement and environmental temperature, muscular work, or any other factor. The second series confirms the findings of the first to the effect that the elephant's ears are not moved primarily to aid in heat loss but as a result of nervousness or excitability, possibly irritability. In the case of a small African elephant recently observed, there was a close

association between the ear movements and anything unusual or alarming in its environment. The movement of the elephant's ears may be compared to the well-known alert erection of the ears by the horse. It is only when studying the elephant during the night, when disturbing noises are for the most part absent, that one can associate ear movements with other factors. At an environmental temperature as high as 30 degrees C., for example, the ear movement was not significantly different from that at a temperature 10 degrees lower.

Sleeping positions.—Elephants, when on tour, are rarely seen lying asleep during the daytime. Their lives are relatively strenuous. Their nights are usually spent in cramped quarters in elephant railroad cars, where it is practically impossible for them to recline. As a result one may see a few elephants lying asleep in the latter part of the afternoon, although this seldom happens when a crowd of onlookers is passing by. At night the animals almost invariably lie down when they have an opportunity. During the several weeks' stay of the Ringling Brothers Circus at the New York Garden or during the week's stay at the Boston Garden the elephants usually lie down at night, although not often before midnight, and they are standing and awake in general at not far from 4.30 or 5 A.M. Apparently there is little, if any, difference in the position of sleeping with most of the animals. They may sleep on either the right or the left side, depending upon which position means the least interference with their neighbors. The smaller African elephant of the Ringling herd assumed an unusual position in sleeping, placing her hind legs almost directly under the body and lying on the side of the front part of her body. This animal was featured by the New York press as the elephant that slept "standing on its head." Like humans, as has been shown in many recent studies of humans during sleep, the elephant frequently changes its body position while sleeping. This change pertains not so much to leg movements as to movements of the entire body from the lying to the standing position, and then to the lying position again. Elephants, if lying, stand up approximately once an hour, either to urinate or to defecate. Occasionally they defecate while lying but never urinate in this position. The elephant, like the horse, can and does in many instances sleep while standing. Under these conditions the trunk rests on the ground, the lower end curled up slightly but immobile, in striking contrast to its restlessness when the animal is awake. The degree of trunk movement may well be taken as an index of whether the animal is asleep or awake. No more striking difference in the muscular activity of a herd of elephants can be imagined than the difference between the muscular activity at 11.15 P.M., when visitors are passing out of the animal quarters in the New York Garden after the evening performance, and that an hour or two later. At 11.15 P.M. every elephant is alert and in motion, not necessarily reaching for food from the visitors but obviously stimulated by the hue and

cry incidental to this phase of circus life. Two hours later half of the herd or more may be lying, sound asleep, and the other half may be standing quietly, moving their trunks around to bring a wisp or two of hay to the mouth. On one occasion the entire herd was so motionless (approximately half of them lying and the other half standing with the trunks resting on the floor in the sleeping position) that a still-life, time-exposure photograph could easily have been taken of the herd. However, this repose of the entire group continues for only a relatively short time during the night, and one marvels at the endurance of the elephant in its ability to be for hours in incessant motion with no rest. This fact of itself implies that the constant muscular activity is accomplished with but small drafts upon the energy to be derived from body material or food.

Teeth.—The anomalous anatomical feature of the highly developed tooth structure of the elephant, which is inexplicable in view of the absence of any considerable use of the teeth, warranted the search for further data regarding the teeth. Elephant men were cautioned two years ago to be on the lookout for particles of teeth or whole teeth in the feces of this animal, for it is commonly believed and not uncommonly stated that the elephant's teeth are lost by being pushed forward and ejected *in toto*. Although several scores of elephants have been under observation for the last two years, partly by us but chiefly by the intelligent head keepers, and although recently frequent examinations have been made of the feces and of the condition of the teeth of the elephant by having the mouth opened, no whole teeth have ever been noted as lost. On the other hand, on several occasions fragments of teeth have been found in the feces. Hence it would appear that the teeth, when lost, are not lost whole but in fragments.

Eating and chewing.—Perhaps the chief occupation of the circus elephant or the elephant on exhibit is eating. The muscular movements in eating are small and few, the trunk picks up wisps of hay and carries them to the mouth, and there is a remarkably small amount of chewing. These facts all contribute to the conception that the muscular activity of the animal when not weaving is accompanied by a small energy demand. The appetite of the elephant, however, is insatiable and seems never to be appeased. This may be explained on several grounds. In the first place, the elephant is an enormous animal with a high heat production. Furthermore, the digestibility of the hay eaten is lower with the elephant than with any other animal that has been studied. Only about 40 per cent of what the elephant eats is digested. The result is that it must eat a great deal of food in order to maintain its body weight. Consequently the elephant is continually searching for food, picking over hay whenever any is in sight. As it is restless when food is not available, it must be fed 8 or 10 times per day. The picking up of hay, its transportation to the mouth by the trunk, and the incomplete chewing of the hay constitute what might be called a reflex action on the

part of the animal. A striking illustration of the persistence of this combination of movements was furnished by one of the largest of the Ringling herd (Palm), which was called upon to push a van. She was perhaps one hundred yards from the van. As she started toward it, she picked up some hay and, in spite of the vociferous commands on the part of her keeper, this hay was put into her mouth. By the time she reached the van, she had picked up some more hay and, while pushing the van, her mouth was moving, the trunk was raised to the mouth, and this hay was put in place. This incident gave further confirmation of the incessant trunk-to-mouth motion of these animals in their efforts to secure food.

Hearing.—The experience in the earlier series of observations showed that the hearing of the elephant is acute. The instant recognition of its own name and the complete disregard when a name other than its own is called are always challenging. On one particular night a good opportunity was had to note the extreme sensitivity of hearing. One of the larger elephants of the Ringling herd, Eva, had shown by her general good nature that she was a particularly tractable animal with which to work. It was desired to have her lie down so that electrodes could be applied to her front feet to obtain records of the heart rate. She remained standing for a long time, playing with the hay and showing no disposition to lie down. The intelligent night watchman, Mr. John Shayne, stood near her and in a low voice said, "Come on down, Eva." This was repeated 3 or 4 times, but at no time in a voice much above a whisper, and shortly this elephant, which had shown no disposition to lie down before this, slowly settled into place, rested her head on the concrete floor, and almost immediately went to sleep.

Reaction to rats and mice.—The time-honored legend with regard to the supposed terror that the elephant, the largest terrestrial mammal, has of the mouse, almost the smallest terrestrial mammal, has so persisted that our observations on this subject are worthy of record. As the food of the elephant is chiefly hay and as hayseed is relished by mice and rats, captive elephants, especially in zoological parks, are almost continually in the presence either of mice or of rats. This infestation varies in different localities. One large zoological park, for example, has only rats. At this park when hay is thrown out to the elephant in the late afternoon in winter, we have frequently seen a number of rats come scurrying out almost immediately to pick up the seed. On such occasions the elephant has been entirely undisturbed by the presence of the rats, and the rats have been undisturbed by the elephant. In another park there are not rats but mice. These mice scurry around at will and enjoy the hayseed and any bits of bran or concentrate feed left by the elephant. It would, therefore, appear that the elephant does not have an inherent, morbid fear of these small rodents. The question arose as to whether elephants that are accustomed to having rats around would be unduly disturbed by the presence of mice, for usually rats and mice

do not frequent the same locale. The claim is made that elephants are not disturbed by animals or vermin to which they are accustomed. The white mouse is certainly not the usual inhabitant in elephant quarters. We, therefore, took some white mice to the Franklin Park in Boston and placed them on the floor in front of the two elephants there. Neither was the slightest bit interested in or disturbed by the presence of the mice. The mice were placed on the elephants' trunks and allowed to crawl around at will. The elephants made no attempt to shake them off. Occasionally they would curl up their trunks or sniff at the mice, but there was no hint at any time of any fear or disturbance. It is, therefore, clear that much of this legend must be dissipated. This does not lessen the fact, however, that elephants are inordinately disturbed or frightened by unusual noises, such as the barking of a strange dog. If a rat scurried over a newspaper lying on the floor, the noise would challenge the attention of the elephants, and if they were lying down, would undoubtedly cause one or more of them to give an alarm, to which all the elephants would react by trumpeting. Elephant men are continually on guard against strange noises. This may seem inconsistent, in view of the ordinary furor and turmoil attending circus movements from one town to another, but the disposition of the elephant to stampede or to "blow up" is well known and has been only too frequently experienced by elephant trainers.

Body weight.—The great weights claimed by hunters for their various kills are usually so uncertain as not to justify scientific consideration. At the time of the appearance of the Carnegie monograph on the elephant, the heaviest weight that we were willing to accept as accredited was the 12,000 pounds attributed to the Indian elephant Bolivar by Dr. Herbert Fox of the Philadelphia Zoological Garden. Recently, on an expedition to Africa, Dr. George Crile of Cleveland, Ohio, shot a gigantic African bull, and as Dr. Crile was particularly interested in the relationship between brain weight and body weight, provisions were made for weighing this huge animal in the field. At the moment of writing, his complete report has not yet appeared. Mrs. Crile (1936), in her most interesting book entitled "Skyways to a jungle laboratory," stated that this elephant weighed 14,641 pounds. This is a weight 1.25 tons greater than that of Bolivar. Correspondence with Dr. and Mrs. Crile and their associate, Dr. Quiring, shows that the scales taken into the field were capable of weighing 600 pounds. They had been carefully checked and calibrated. The elephant's body was cut up and weighed in pieces, the smaller portions being weighed on proportionately smaller scales with greater sensitivity. Owing to the fact that there was a large loss of blood and body fluids by seepage into the gravel and sand of the dried river course where the animal fell, the authors have made what in our judgment is a modest allowance of 10 per cent of the body weight for seepage. Quite irrespective of the fact that this weight of somewhat over 14,500 pounds may

be considered in the nature of a "record" weight, it is an important observation that these huge animals can attain such a size, exceeded among mammals only by the whale, although there is a great difference between the weight of the largest elephant and the weight of one of the larger species of whale.

Height.—An opportunity was had to measure the heights of several elephants of the Ringling herd that had not previously been measured, and special attention was given to the heights of the two small African elephants. These heights were determined by the simple cross-arm device already described in the monograph, with the use of either a plumb bob or a spirit level. The terrain was not ideal, although the most level piece of ground was sought. The height at the shoulder was measured by using the levelled bar of the cross arm. The distance over the shoulder, from the ground at

TABLE 1

Heights of elephants

ELEPHANT	HEIGHT AT SHOULDER	DISTANCE OVER SHOULDER FROM GROUND TO GROUND	CIRCUMFERENCE OF FRONT FOOT[1]	HEIGHT AT SHOULDER	HALF THE DISTANCE OVER SHOULDER FROM GROUND TO GROUND	TWICE THE CIRCUMFERENCE OF FRONT FOOT
	ft. in.	*ft. in.*	*ft. in.*	*meters*	*meters*	*meters*
Indian						
Margaret	7 9½	17 2	3 11½	2.37	2.62	2.40
Big Eva	7 6	16 7½	4 2	2.29	2.53	2.54
Trilby	7 8	16 5½	3 7	2.34	2.51	2.18
Nellie	7 5¼	15 11½	3 8½	2.27	2.43	2.25
African						
Sudan	5 0	10 9½	2 6	1.52	1.64	1.52
Puqua	5 1½	11 1¾	2 4¾	1.56	1.70	1.46

[1] Left front foot in case of Indian elephants and right front foot in case of Africans.

the outside of the right foot to the ground at the outside of the left foot, was likewise measured, and the traditional measurement of the circumference of the front foot was made for comparative purposes. The data obtained, expressed both in meters and in feet and inches, are summarized in table 1. The last two elephants listed were small African elephants, of which Sudan was considerably older than Puqua. The weights of these several elephants were not even estimated, nor were their approximate ages noted. They were good examples of large circus elephants, averaging probably not far from 6500 to 7500 pounds, and their ages were probably about 25 to 35 years. The measurement of one-half the distance over the shoulder from ground to ground was, as is to be expected, invariably larger than the vertical height at the shoulder. Even with the much smaller Africans the error was

considerable. The measurement representing twice the circumference of the front foot showed deviations from the measured vertical height at the shoulder ranging from +25 to −16 cm. in the case of the four Indian elephants, which emphasizes the unreliability of this classic (!) method of measurement. In the earlier series no elephants as small as the two Africans were studied. Consequently these animals will be omitted from consideration in making comparisons with the earlier series. None of the elephants in the earlier series were under 2 meters in height. Their average height was 7 feet 4 inches, or 2.24 meters. The average height of the 4 Indian elephants in the second series was slightly higher than this. With the first 4 elephants in table 1 the measurement representing one-half the distance over the shoulder from ground to ground is, on the average, 21 cm. greater than the vertical height at the shoulder. This is about the same as the average difference noted with the elephants in the first series and confirms the conclusion that the true height of the elephant can be obtained by throwing a tape over the shoulder, measuring the distance from the outside of one front foot over the shoulder to the outside of the other front foot, dividing this by 2, and subtracting from the quotient 19 cm. or, in case the elephants are taller than about 2.2 meters, subtracting 21 cm.

Feces.—As the two small African elephants were available for observation, attention was concentrated upon them in the collection of both feces and urine for microscopic examination and for temperature measurements. Although the weights of these animals were not determined, it can be seen from their measured heights (table 1) that they were considerably smaller than the Indian elephants. With Sudan the last bolus of a series of 5 and with Puqua the third, fourth, fifth, and sixth boluses of 7 boluses of feces passed, were individually collected, measured, and the temperature of the same recorded. The boluses were of a different form from those of the large Indian elephants in that they were more distinctly shaped like a disk. The maximum diameter of the boluses was 121 mm. and the thickness of the disk-shaped boluses varied from 59 to 76 mm. The weights ranged from 269 to 453 gm. Whether the difference in shape of the feces bolus of the African elephant (more oval in cross section) as compared with the bolus of the Indian elephant is due to a difference in size of the animal (we have never measured any Indian elephants as small as these Africans) or whether it is due to a difference in the configuration of the alimentary tract, particularly the lower bowel, is not known.

Parasites.—Because of the almost invariable infestation of wild animals by parasites, intelligent elephant men make strenuous efforts to keep their animals free from parasites and, as a result, most of the circus elephants are free from gross or macroscopic parasites. All the elephant feces examined in the first survey were free from parasites. During the winter of 1937 one of the 3 African elephants belonging to the Ringling Brothers Circus died at

Sarasota, Florida. Captain Lawrence Davis and Dr. Dean S. Luce were thoughtful enough to dissect the animal carefully and to send to the Nutrition Laboratory specimens of a considerable number of bots found attached to the stomach wall. In fact, the stomach wall was almost completely covered with these bots. They were similar in form to the well-known horse bots. We were fortunate enough in being able to have these inspected by Dr. Joseph C. Bequaert of the Department of Tropical Medicine, at the Harvard Medical School. He has had extensive experience in the field with African elephants and reports that he has never dissected one of these animals without finding these bots in the body. He states that usually when these elephants are taken to another country the bots persist for about a year, but as they need a certain type of soil to complete their life cycle, they disappear at the end of the second year. Because these bots are usually found in every African elephant and in amounts not materially different from those reported by Captain Davis and Dr. Luce, Dr. Bequaert was certain that the elephant had not died as a result of this body infestation. The feces of the two other African elephants were examined at the Eastern Maine General Hospital in Bangor. In each case the feces represented one bolus from one defecation on June 23, 1937. At this time, nearly 15 months after these animals had left Africa, no bots were observed, although it is more than likely that they would appear in the feces only at certain periods, which might not have coincided with the date on which their feces were examined at Bangor. Specimens of feces from both these animals were sent to the laboratory of Dr. H. E. Thompson, of the Eastern Maine General Hospital, for microscopic examination, with the following results:

Elephant Sudan: "No ova found. Short pieces of hay. Dark, sticky material. Microscopic examination shows vegetable cells, spirals, and motile bacilli (B. coli)."

Elephant Puqua: "Specimen shows a large amount of short pieces of hay with dark colored, sticky material. Microscopic examination shows vegetable cells and spirals with occasional crystals that resemble uric acid crystals. No ova found. Bacteria (B. coli)."

It is thus seen that there was nothing abnormal about the feces of these 2 African elephants. We are somewhat at a loss to know why the microscopic examinations of the feces of circus elephants that we have studied differ so widely from the invariable experience of Professor C. A. Kofoid of California. In the feces of wild elephants, especially in Siam, he found many parasites, as is to be expected. But in the case of a large captive elephant killed in San Francisco in the spring of 1936 and examined by him, he reported (private communication) that the "usual parasites were found."

Urine.—Samples of urine were collected from 7 of the elephants in the Ringling herd in June 1937. Time did not permit of chemical analysis but, thanks to Dr. Thompson, of the Eastern Maine General Hospital at Bangor,

the specimens were examined in his laboratory. Special interest centers around the examination of the 2 specimens from each of the African elephants, Puqua and Sudan. There was nothing out of the ordinary in the characteristics of their urines, save for a possible trace of sugar in one of the specimens (no. 10) from Sudan. In all these samples there was an absence of albumin, sugar (except no. 10), indican, diacetic acid, and acetone. The urines were straw-colored and cloudy in appearance, except for nos. 5 and 9 which were clear. The reaction was alkaline in all instances. The urines of all these elephants contained large amounts of calcium oxalate crystals, just as in the case of the elephant urines examined in the earlier survey. In no. 1 there were rare leukocytes and in no. 12 occasional epithelial cells.

TABLE 2

Temperature and specific gravity of urines of Ringling elephants collected at Bangor, June 23, 1937

ELEPHANT	SAMPLE NO.	TEMPERATURE	SPECIFIC GRAVITY[1]
		°C.	
Indian			
Eva[2]	1	36.0	1.022
Nellie	3	36.0	1.012
Margaret	5	—	1.012
Myrtle	11	35.6	1.017
Trilby[2]	12	35.9	1.027
African			
Puqua	2	—	1.018
"	9	36.6	1.016
Sudan	7	36.3	1.018
"	10	—	[3]

[1] Determined in the laboratory of Dr. H. E. Thompson of Bangor, Maine, June 24, 1937.

[2] Not the Ringling elephant of the same name in the Bangor 1935 series.

[3] Not a sufficient quantity to determine the specific gravity.

The specific gravities (see table 2) ranged from 1.012 to 1.027, but in none of the 8 instances in which a sufficient quantity of urine was collected for examination was the specific gravity as low as 1.004, as was noted in the earlier series with 2 elephants of the Barnes herd. The average of the specific gravities recorded in table 2 is 1.018 or almost the same as the average of 1.019 reported for the earlier specimens that were examined.

Methane production.—Although the elephant is not a ruminant and apparently food remains in its alimentary tract for only a relatively short time, large amounts of intestinal gases are formed. The explosive violence with which these gases are discharged can be noticed by anyone who is about the animals. This is notably the case at night, when the elephants are

lying and reasonably quiet. Not only can the rumbling of gases in the stomach be heard easily (which is perhaps surprising, as it is practically impossible to hear the heart beat with a stethoscope) but particularly the discharge from the anus. Attempts were made to secure samples of the intestinal gases in order to obtain some hint as to the amount of methane discharged in this manner. The early attempts at Sarasota were unsuccessful, but thanks to the assistance of the elephant men in the spring of 1937, 3 samples were collected and subsequently analyzed. For this purpose a basketball bladder was connected with a metal tube having an internal diameter of about 15 mm. This had a rubber tube on the end, which was inserted well up in the capacious rectum. By exercising the elephants the intestinal gases were discharged and the bag was distended. The first bagful of gas thus collected was used merely to sweep out the bag. The bag was then emptied and another bagful collected, from which samples were drawn for analysis. Three samples from as many elephants were secured in this manner. These were analyzed by Mr. George Lee at the Nutrition Laboratory, with the following results for the intestinal gases:

Elephant	CO_2 p. ct.	O_2 p. ct.	*Methane* p. ct.
Eva	21.7	2.5	47.8
Queen	18.7	3.0	43.7
Myrtle	25.8	—	44.3

In view of the unscientific manner in which the intestinal gases were collected (and yet expediency made it necessary to adopt this method), the uniformity in the methane content is striking. This varied only from 43.7 to 47.8 per cent, which demonstrates that a considerable proportion of the intestinal gases given off through the rectum consists of methane. The carbon dioxide content was likewise material, ranging from 18.7 to 25.8 per cent. The oxygen content was determined quantitatively in only two samples, being 2.5 and 3.0 per cent, respectively. In another specimen (Myrtle) the oxygen was estimated by the analyst to be "not over 4 per cent". It would appear that in the elephant there is an almost perfect condition for anaerobic fermentation, the intestinal gases being made up of not far from 50 per cent methane, about 20 per cent carbon dioxide, 2.5 per cent oxygen, and the remainder nitrogen. In the respiration chamber, experiments with the elephant Jap (weighing 3672 kg.), it was found that the 24-hour methane production averaged 655 liters, of which one-fourth was eliminated through the trunk and the mouth and three-fourths through the anus, and that for every 100 volumes of carbon dioxide eliminated there was a total discharge of 4 volumes of methane. It was also demonstrated that the high percentage of methane in the air discharged through the trunk and the mouth could not be a result of eructation but must be absorbed from the alimentary tract by the body fluids and carried by the

circulation of the blood to the lungs, from which it is diffused into the air leaving the lungs.

Respiration rate.—Owing to the incessant activity of the trunk and the difficulty of seeing the distention of the abdomen or the chest as a result of inspiration, the counting of the respiration rate of the elephant when standing is uncertain. The best measurements were made in the 10-day period of observations on Jap, and the conclusion was reached that the respiration rate of the elephant when standing awake is normally about 10 per minute. The change in the rate of respiration immediately after the elephant lies down, which decreases to half the normal rate, is extraordinary. This is usually during a period when the animal is asleep or at least apparently asleep, and yet on one occasion an elephant was found with a respiration rate of 10 although "apparently asleep". In this supplementary series of observations attempts were made to measure the respiration rate only of those elephants that were lying, and during the course of a study of the heart rate frequent measurements of the respiration rate were made while the elephants were in this position. On May 5, 1937, at 3.03 A.M., Liz, when lying, had a respiration rate of 5 per minute. On May 5 Eva had a rate of 6 per minute at 3.35 A.M., 5 per minute at 4.06 A.M., and 6 per minute at 4.22 A.M. At the time of the study of the Ringling herd in Bangor, June 23, 1937, a few of the elephants were lying in the afternoon. At 2.15 P.M. Hazel had a rate of 5 and at 2.24 P.M. Mary had a rate of 6 per minute. In the early morning in May, 1936, one of the African elephants (Puqua) had a respiration rate of 5 per minute, which indicates that the low rate of respiration is by no means solely the result of size. The almost instantaneous adjustment of the respiration rate to this low level, literally a few seconds after the elephant has settled to the floor in the lying position, is striking. The decrease is so pronounced that one might almost consider this low rate as an indication that the elephant has passed into deep sleep. In many instances the seeming insensibility of the elephant likewise indicated that it was in deep sleep. It seems to be a characteristic of the elephant to have this low respiration rate when lying down and asleep. In many cases, however, the low rates were noted even when the elephant was not asleep, as evidenced by the fact that its eyes were open and looking about, although there were no major muscular movements. Although the elephant's trunk assumes a characteristic position when the animal is going to sleep, it is not inconceivable that a well-conditioned elephant might readily be attached to a spirometer and more complete respiratory studies made without too great difficulty.

Heart rate—The anomalous finding that each of 17 elephants earlier studied had a somewhat higher heart rate when lying than when standing led to further observations on this point. It is impossible to determine the elephant's heart rate by other than electrical means, but we were fortunate

in having, in addition to our own apparatus, an equipment loaned by the Sanborn Company of Cambridge, Massachusetts, and in charge of their engineer, Mr. James L. Jenks, Jr., who obtained a number of electrocardiograms of the elephants. These, however, require such special analysis that they are being studied and will be reported elsewhere in conjunction with Mr. Jenks and Dr. Paul D. White of the Massachusetts General Hospital. In April, 1937, with the original modification of the Boas cardiotachometer used in our first study, the heart rates of a number of elephants were recorded, both in the standing and in the lying position (see table 3). Practically all of the measurements were made during the night, for it was desired to study the elephants in the lying rather than the standing position. Incidentally a few observations were obtained on other elephants while standing, and to make the records complete, these are included in table 3. When the elephants were lying the attempt was made to avoid the original technique of having the observer hold the electrodes on the soles of the feet, for it was thought that this might possibly have stimulated the animal and thus have accounted somewhat for the high heart rates noted when the elephants were lying. Because it was observed, however, that the two night watchmen were continually walking about these animals, stepping over their legs and feet apparently unnoticed by them, we were convinced that the presence of the observer was without effect. In a few observations made with the electrodes held in place, the elephants were not sufficiently stimulated for the heart rate to be altered. Nevertheless, to rule out this factor completely the electrodes were successfully attached by adhesive plaster to at least two of the elephants when lying. The first efforts were made with Liz. This animal had been lying for about 25 minutes. When the electrodes were held in place, the heart rate was not far from 42 beats per minute. The contacts were then strapped in place, and the 3 succeeding records were much lower, 37, 36, and 35.5. At 3.06 A.M., shortly after it had been necessary to readjust the electrodes, a rate of 44 was recorded. Soon after this Liz stood up, when the rates were 42 and over. In the case of the elephant Hattie, which had been lying for some time, the electrodes were held on by hand, and the heart rate was 42 beats per minute. The average rate of 42 supports the earlier finding that the heart rate is usually higher in the lying position.

The most extensive series of observations was made with a most tractable elephant, Eva, which was studied from 12.07 A.M. to 4.28 A.M. The standing rates obtained at the start averaged 34 beats per minute. The elephant lay down at 3.29 A.M. by command. The electrodes were strapped onto the front feet at 3.45 A.M., and thereafter the observers remained a considerable distance behind the animal so that they could not be seen. The elephant appeared to be unaware of their presence and soon was in deep slumber, with a respiration rate of about 6 per minute. Under these condi-

tions the heart rate was over 40. At 4.07 A.M. an elephant hook was dropped accidentally, when the rate increased to 44, but subsequently it

TABLE 3

Heart rates of elephants (May 5, 1937)

ELEPHANT	TIME	BODY POSITION	HEART RATE PER MIN.	ELEPHANT	TIME	BODY POSITION	HEART RATE PER MIN.
	a.m.				a.m.		
Tillie	12.40	Standing	36	Eva	12.07	Standing	36
					12.30	"	31
Juno	12.45	"	34			"	32
					12.34	"	35
Little Modoc	1.21	"	34		1.10	"	37
		"	36				
		"	34		3.51	Lying[1]	35
		"	37		3.55	"	41
						"	40
Babe	1.46	"	39		3.56	"	42
						"	42
Queen	1.53	"	30		3.57	"	42
					3.58	"	41
Liz	2.53	Lying[2]	[3]42		4.00	"	42
	2.57	"	[3]43		4.02	"	42
	3.00	"	[4]37		4.04	"	42
		"	[4]36		4.06	"	42
	3.03	"	[4]35½		4.08	"	[5]44
	3.06	"	[6]44		4.10	"	42
	3.10	Standing	46		4.13	"	41
	3.12	"	44		4.15	"	41
		"	44		4.17	"	[7]45½
	3.14	"	42		4.20	"	39
					4.22	"	39½
Hattie	—	Lying[8]	42		4.23	Lying[9]	35
					4.25	"	35
					4.26	"	38
					4.28	"	39

[1] Lay down at 3.29 a.m. by command; asleep until 4.23 a.m.
[2] Had been lying for 25 minutes.
[3] Electrodes held in place by hand.
[4] Electrodes strapped in place.
[5] At 4.07 a.m. an elephant hook was accidentally dropped.
[6] Contacts readjusted between 3.04 and 3.05 a.m.
[7] At 4.16 a.m. Eva was touched by elephant next to her.
[8] Lying for some time; electrodes held in place by hand.
[9] Awake.

returned to a level of about 42. Two records obtained just before the animal awoke showed rates of 39 beats. At 4.23 and 4.25 A. M., when Eva was

awake but still lying on her side, two observations showed heart rates of 35, and at 4.26 A.M. and 4.28 A.M. or shortly before she stood up, the rates were 38 and 39. The general picture is that the elephant had a higher heart rate while lying than while standing. Of especial interest is the fact that when she was lying awake, a rate of 35 was found at one time. That the elephant was awake was evidenced by the fact that the eyes were open and that in order to keep it in the lying position it was fed sugar, which resulted in trunk movements, searching for the sugar and lifting the end of the trunk to have the sugar dropped into it.

Although the observations recorded in table 3 are much less extensive than those obtained in the earlier series, the picture as a whole confirms the earlier work, as do also the counts from the electrocardiographic films made in 1936. Thus far, however, there is no explanation of why the heart rate should be higher when the elephant is lying. It is, furthermore, striking that in at least one instance (Eva) when the elephant was lying and awake, the heart rate, which had been about 42 per minute while it was lying asleep, should have slowed to essentially that noted when the animal was standing. It would, therefore, appear that the heart rate is influenced not only by the body position but by the state of consciousness. These problems will be considered in the analysis of the electrocardiograms, which is to be published elsewhere.

Feces and urine temperatures.—In the earlier survey it was found that the temperatures of the urine and also of the feces were uniform, but that the feces temperature was higher than the urine temperature due to fermentation processes. In the supplementary observations a few of the elephants not previously studied were measured, with especial emphasis on the two Africans. The body temperature measurements in this latter instance included observations on the temperatures of the feces, the urine, and the skin. Two defecations by Trilby, one at 3.15 P.M. and one at 3.33 P.M., had temperatures of 36.1 and 36.6 degrees C., temperatures quite in accord with the earlier findings. With the African elephant Puqua the temperatures of 4 separate boluses ranged only from 36.2 to 36.6 degrees and averaged 36.4 degrees C., or almost the same as the average noted for all of the elephants in the first study. Judged from the measurements on this one elephant, therefore, the feces temperature of the African elephant may be expected to be the same as that of the Indian elephant. In the securing of the urine specimens for microscopic and chemical analyses precautions were taken to collect them in previously warmed thermos jars, in order to obtain simultaneously the temperature of the urine. Occasionally the volumes were very small, and the temperatures of these specimens were uncertain. The temperatures recorded in those instances when a sufficient amount of urine was voided are listed in table 2.

Skin temperature.—A special study of skin temperature was made in Boston

with the Ringling herd in the spring of 1936. The skin temperatures of these animals seemingly should have great significance, owing to the fact that the surface of the elephant's body is unprotected by fur, although there is a scattered distribution of hair in certain parts of the body, notably on the lip, around the ears, and sparsely on other parts of the body. In other words, the elephant is practically a hairless animal of large size, exposed to the temperature of the environment existing at the time. The first skin temperature study was made in 1921 at the New York Zoological Park (Benedict, Fox, and Baker, 1921a, 1921b), when it was found that the differential between the average skin temperature of the elephant (about 25.5 degrees) and the environmental temperature (held constant at about 19.5) was approximately 6 degrees C. The elephant Jap in 1935 at a much lower environmental temperature (16 degrees) had an average skin temperature of 26.5 degrees C. Here the differential was 10.5 degrees C., although the skin temperature was actually somewhat higher than in the case of the elephants at the New York Zoological Park. Four of the Ringling elephants were studied at Sarasota, Florida, under not ideal conditions, at a fairly high environmental temperature averaging 25.3 degrees, and with differences in prior exposure to the sun. In these instances the average skin temperature was 30.3 degrees C. The differential was, therefore, 5 degrees C., this being almost exactly the same as the differential noted with the Indian elephant at the New York Zoological Park in an ideal, quiet, and uniform environment.

Because of the uncertainty in these measurements further study of the skin temperature was desirable, and hence in the spring of 1936 a large number of measurements were made on 31 of the elephants in the Ringling herd when they were in Boston. The 16 locations on the body at which the measurements were made were the same as those in the earlier study on the Ringling elephants (Benedict, 1936). The measurements at positions 5 and 5a were on the ear. The measurement at position 5b was on the head, slightly above and behind the left eye. In table 4 are reported the average skin temperatures of the different elephants, based in each instance upon the measurements at the 16 different parts of the body. Lack of space makes it impossible to present all of the several hundred measurements made. The highest skin temperature noted in the entire series was with Mary, namely, 34.0 degrees C. at position 10 over the rump. The elephants were so chained that the sunlight coming through very dirty windows fell upon their backs, and possibly a number of these skin temperature measurements were influenced by diffused sunlight.

The differential between the room temperature and the average skin temperature varied greatly. On the afternoon of May 7 the room temperature was not far from 22 to 23, and the average skin temperature about 27 or 28 degrees, which means that the differential in general was approximately 5 or 6 degrees C. Modoc at 2.45 P.M. on May 7 and again at 2.52 P.M.

on May 8, after having been in the exhibition hall, had an average skin temperature lower than that of any of the other elephants. The exhibition hall was much cooler than the stalls where the elephants were kept, and in spite of Modoc's muscular activity (which, however, lasted at the most for not more than 3 minutes) the skin temperature had been affected so much by the temperature of the hall that it had not increased as a result of the exercise. In the evening of May 7 the differential was wider than in the

TABLE 4

Average skin temperatures of Ringling elephants[1]

DATE AND ANIMAL	TIME OF DAY	ROOM TEMP.	AVG. SKIN TEMP.	DATE AND ANIMAL	TIME OF DAY	ROOM TEMP.	AVG. SKIN TEMP.
	p.m.	*°C.*	*°C.*		*p.m.*	*°C.*	*°C.*
May 7, 1936				May 8, 1936			
Modoc[2]	2.45	22.2	24.0	Modoc[2]	2.52	27.1	30.6
Yasso	2.53	22.4	25.5	Trilby	2.59		31.9
Nellie	3.00	22.3	27.5	Babe	3.06		32.2
Modoc	4.09	21.2	27.5	Clara	3.18	26.4	31.9
Juno	4.16	22.2	27.2	Marcella	3.42		31.4
Jewel	4.24		29.7	Jess	3.47		31.9
Katie	4.31	22.6	27.3	Bingo	3.51		32.9
Blanche	4.37		28.9	Mary	3.57		32.7
Tillie	4.43		28.5	Mabel	4.01		32.4
Fannie	4.48	23.6	28.5	Eva	4.12		32.1
Sudan	8.53	21.4	27.7	Palm	4.16		31.5
Queen	9.13	21.6	29.1	Pinto	4.19		30.7
Topsy	9.20	21.7	29.7	Wilhelmina	4.25	25.3	29.3
Liz	9.28		30.5				
Bunny	9.37	21.7	30.5				
Hazel	9.43		29.7				
Alice	9.50		29.2				
Hattie	9.57		28.9				
Myrtle	10.03	21.7	29.5				
Yasso	10.14		29.8				
Jennie	10.28	21.8	29.5				

[1] Indian elephants with exception of Sudan, a small African.

[2] After act.

afternoon. The environmental temperature in the evening was somewhat under 22, the average skin temperature about 29.5, and the differential was almost 8 degrees C. On May 8 it was very warm in the elephant stalls, and the average skin temperature was much higher in practically all cases, but the differential was not extremely great, being about 6 degrees at the maximum.

The influence of the environmental temperature upon the skin temperature is not a linear one by any means. It would, therefore, seem to be impossible

to calculate the heat loss of the elephant from the measured skin temperature and the temperature of the environment. Whether there is a marked change in the amount of water vapor given off from the skin at the higher temperatures is not known. The elephant's skin as a rule is fairly dry and hard and does not give the impression of being moist. The measurements in table 4 are recorded as a contribution to elephant physiology, but the alterations in environmental temperature were such that the series was by no means so perfect experimentally as the series of observations on the elephants at the New York Zoological Park in 1921, when a difference in temperature of about 6 degrees was found. We would caution against any attempts to compute the heat loss on the basis of the differential between the skin temperature and the environmental temperature. The number of body locations measured, although fairly large, may not be sufficient to represent the true temperature of the entire surface area of the elephant. However, it is striking that when all the measurements at a given position on the body

TABLE 5

Average skin temperature at different positions on the elephant's body (May 7 and 8, 1936)

POSITION	AVG. TEMP.	POSITION	AVG. TEMP.
	°C		°C
1	29.2	7	29.7
2	29.2	8	30.1
3	29.3	9	30.3
4	29.0	10	30.7
5	28.8	11	30.3
5a	29.3	12	30.4
5b	29.9	13	30.4
6	28.9	14	29.2

are averaged, as has been done in table 5, the differences between the average temperatures at the various positions are small. The lowest average temperature is 28.8 at position 5 and the highest is 30.7 degrees at position 10. In other words, the maximum difference is but 2 degrees C. Based upon this study alone, therefore, it would appear as though increasing the number of positions for observation would not materially influence the values found for the average skin temperature.

It is obvious that these large animals with their hairless surfaces present an unusually interesting problem with regard to the method of heat loss. What proportion of the heat is lost by direct radiation and what proportion by convection? In view of the great height of the elephant one can imagine that the convection factor plays a large rôle. Variations in the amount of water vapor given off should also be taken into consideration, with reference not only to the amounts given off from different parts of the surface of the body but to the effect of changes in environmental temperature.

Further elephant research needed.—These observations are admittedly of a fragmentary nature, but as precise physiological measurements on the elephant are so infrequent, they seem worth recording. Further observations on elephants are greatly desired. Certainly the elephants in zoological parks are available for study by most clinics and institutional laboratories in the larger cities. It so happens that since the elephant memoir (Benedict, 1936) was published, 3 elephants have either died or been killed in the United States, and in each case we were unable to contact the proper authorities in time to secure data of any value. These animals were simply turned over to a rendering plant or buried. We wish to enter a plea to the men in charge of zoological parks and circuses that when elephants are to be killed, scientists be notified so that they can profit by the dissection of these highly interesting animals. It is unnecessary to make a complete list of the important observations still to be made and easily made upon elephants that are being dissected. Further data on the teeth, the intestinal flora, the weight of the intestinal contents, and the weights of various parts of the body in relation to the total body weight are only a few of the observations that would be of great value.

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OTTERS OF THE DELTA HARDWOOD REGION OF MISSISSIPPI

By Lee E. Yeager

Lying east of the Mississippi River and reaching from Vicksburg to the Tennessee line, the delta hardwood region of northwest Mississippi comprises more than 10 counties, or roughly one-seventh of the state. This flood plain of 8000 square miles was originally covered by heavy hardwood and cypress forests and interrupted throughout by lakes, bayous, and southernly flowing creeks and rivers. The entire area, until about 1885, was the range of a dense otter population, and other southern river-bottom mammals occurred in probably their maximum numbers. In topography, waterways, timber types, and fauna, this region was, as it still is, similar to the remainder of the Mississippi flood plain, extending from southern Missouri into southern Louisiana.

The developmental history of the delta hardwood area can be summarized by stating that, during the last half-century, the wilderness has been turned into one of the greatest cotton-producing centers in the South. Most of the higher ridges have been cleared and by far the greater part of the lowlands have been lumbered. Woodland now remaining consists largely of second-growth cypress-tupelo gum swamps, stream and lake banks, and some over-grazed lowland and woodlot pastures. Lakes and streams have severely deteriorated from erosion, pollution, and those changes in the physical condition naturally accruing from timber cutting and extreme proximity to man and domestic stock.

As a result, wildlife losses have been heavy, here as in other parts of the Mississippi river-bottom. In the delta hardwoods, the beaver, timber wolf, and "panther" (probably *Felis arundivaga* Hollister) are nearly or quite exterminated. The wildcat, black bear, whitetail deer, and wild turkey are found in small numbers in the largest swamps or wooded lowlands. The otter (probably *Lutra canadensis interior* Swenk) still occurs in some of the larger swamps and lakes. The smaller fur-bearers, such as the mink and raccoon, are far from common over much of the area, and even the opossum is scarce in some intensively farmed localities. The muskrat, striped and spotted skunks, and fox, both red and gray, seldom occurred at any time, except along the eastern and southern borders of the delta. Cottontail and marsh rabbits, and fox and gray squirrels have been reduced to a remnant of their former numbers.

During nearly 30 years of residence in or close association with the region, I have gathered a number of records of otters. For many of the records I am indebted to my grandfather, J. J. Cockrell of Leflore County, who was a delta pioneer in the early 70's, and who, because of nearly 80 years in the woods and fields, is able to supply much of a past and little-recorded era. I am also indebted to the following old hunters and trappers, several of whom

are now deceased, for records, information, and experiences, which I believe to be generally reliable: Billy Winn, Joe Richburg, and Willie Inlow, of Leflore County; Edd Grinder of Sunflower County; and Will Smith, who lived for more than 30 years in a houseboat on the delta rivers. Also available and included herein are a few observations made by myself, and some of the records and experiences of four uncles, who, from 1892 to 1927, spent an aggregate of over 50 winters on delta traplines.

In the early 70's the steel trap began to come into common use in the delta region, and from then on the importance of the rifle in taking furs decreased. Before the day of traps, shooting was about the only way of securing otters, as this species is not easily taken in deadfalls, and snares were then unknown to southern trappers. I have learned that beavers were sometimes taken by surrounding the lodge with stakes, breaking it open, and shooting or clubbing the animals therein. At other times beaver dams were broken for the same purpose. Methods involving the destruction of lodge and dam were probably used less frequently by early delta trappers than by early white and Indian trappers of the north and east. This may have been due to a lack of partnerships among the delta hunters, whereas trappers of the northern sections, especially Indians, commonly worked in small groups, and therefore could effectively employ destructive methods.

My grandfather, who has seen many old-time trappers come out with their winter's catch, states that the average kill up until 1885 or a few years before, was 25 or 30 beavers and 15 or 18 otters. As the country opened up after this date the average annual take decreased steadily.

For the period between 1892 and 1928, I have the following records of otters as taken by delta trappers, which I believe to be reliable. The first 5 trappers in the list, although they kept neither diaries nor detailed records, did tally or were able to recall their otter catches for the periods indicated. In these 5 cases, the number of otters is conservative; in the remaining instances they are as taken from daily or seasonal records of 4 members of my family, a long-known negro tenant (Harris), and the trapper Reed whom I never knew but whose catch of 1 otter in 1928 is indisputable. I have thrown out as unreliable the records of several trappers who boasted much larger catches than any indicated below. In the first 5 cases the method of capture is somewhat uncertain, and I have been forced to arrange that part of the table as given, knowing that it is not exact. I feel confident, however, of the general trend indicated.

The figures show that most of the otters were trapped on logs, for which there is a general reason; the abundance of logs in the lakes and streams, the definite tendency of the species to walk them, and the relative scarcity of steep banks, and therefore otter slides, bordering the waterways. It is significant that Grinder, who trapped the Yazoo, Sunflower, and Vogue rivers, all streams with comparatively high banks, had the highest percentage

of slide-trapped otters. Many of the delta lakes and small streams and most of the swamps have very flat, low, and muddy borders.

The figures also show that the trappers of a generation ago were not averse to destroying otter dens. Practically all the old trappers with whom I talked admitted that it was a trick of the trade, and most of them frankly considered it a stroke of fortune to locate otters in a hollow log, as they could be more easily and surely chopped out of a log than from a tree or stump. Many tree and stump dens had underwater entrances, a factor that would effectively prevent the location of a large percentage of such dens, and even if located, such entrances would serve as an avenue of escape. Very large cypress and tupelo gum den-trees probably contained hollow, underground

TABLE 1

Some Records of Otters Captured in the Delta Hardwoods, 1892-1928

NAME OF TRAPPER	DATE	METHOD OF CAPTURE						
		Trapped			Chopped Out of Den			Shot
		Log	Slide	Den	Log	Stump	Tree	
Richburg, Joe	1892-1912	29	3	2	2	0	1	4
Winn, Billy	1896-1911	17	2	0	3	1	1	3
Inlow, Willie	1899-1905	3	1	0	3	1	2	2
Grinder, Edd	1897-1912	8	6	1	1	0	2	1
Smith, Will	1899-1911	10	2	0	4	0	2	0
Yeager, Jim	1892-1900	6	3	1	1	0	0	1
Cockrell, S	1896-1916	5	1	3	2	0	1	0
Cockrell, E	1899-1912	7	0	0	2	0	1	0
Cockrell, F	1912-1927	5	1	2	3	0	2	0
Harris, James	1906-1923	3	0	0	1	0	0	0
Reed	1928	1	0	0	0	0	0	0
Totals		94	19	9	22	2	12	11

roots or cavities, from which the animals could only with difficulty be removed. Also it is likely that some of the otters secured by chopping were not taken from regular dens, but from temporary refuges into which they had been chased. The table, therefore, gives little indication of den preference.

From the evidence available, I believe that most delta otters, past and present, den in the hollow bases of cypress trees, or in some instances in tupelo gums of the same type. The next largest number probably use hollow logs of the same tree species. A comparatively few bank dens constitute a third class, and these three types undoubtedly represent most of the dens found in the region.

I have been fortunate in obtaining the descriptions of two otter dens, both

from Leflore County. One was in the base of a large hollow cypress in the swamp now known as Gayden "brake", and was located and observed in January, 1911, by two uncles, S. and E. Cockrell. This tree stood among a thousand others on the muddy, log-strewn margin of one of the deeper pools in the swamp. A hole in a large root just above the water level served as a den entrance, and when found, fresh tracks showed that 4 otters, 2 large and 2 small, had entered the tree only a few hours before. In keeping with custom, the entrance was plugged, a hole chopped in the shell-like trunk of the 12-foot tree, and one of the otters was quickly shot under the light of a cypress-splint torch. When none of the other animals could be seen, E. Cockrell crawled through the hole into the tree, and with the rifle and torch continued the search. The second of the two large otters was found and shot, far back in one of the hollow roots. These two otters proved to be male and female. The remaining two were never found, probably because they, being smaller, were able to go farther back in some cavity and thus out of sight. They were undoubtedly pups of the current year.

There was little within the protecting cypress shell that could be called a nest. The highest and driest part of the hollow, which may have served as a bed, was directly below the hole chopped in the tree. This area, some 4 or 5 feet square, was littered by a few old leaves, sticks, and decayed bits of wood perhaps chewed or clawed off the inside surface of the tree. The remainder of the floor was of black mud, almost covered with tracks. The sight or odor of stored fish or other food could not be recalled by the two men, and they considered it doubtful if such material was present. There was no standing water inside the tree at the season, although during floods a depth of several feet, much more than enough to eliminate the cavity as an otter den, often occurred.

The brothers plugged the chopped opening with the end of a log, unplugged the root, and set a trap in the entrance runway. The following morning a blundering opossum was in the trap, and the tracks of the two small otters led out of the hollow root.

The second den was in a hollow cypress log at the head of Blue Lake, near the village of Berclair. At this point, Bear Creek forms the head of the lake, and along the creek, the cypress timber had been cut many years before. Tops and logs, weathered and blended with the surroundings and shaded by a stand of defective tupelo gum, almost fill the stream. The water is normally clear, partly covered by lily pads, and abounds in large-mouth black bass and bluegills. My grandfather and I were fishing early one morning in June, 1928, when we found the den. We saw the otter glide out of the water and enter the cavity, which was about a foot above the water surface. The den log was well hidden by several tops and other debris, and its wide, flaring base, a structure peculiar to southern swamp trees, sloped down into the water. This was the only conspicious feature,

and one, it could be imagined, that served ideally as the front porch of an otter den. We paddled up and saw the wet tracks of the animal leading in, and estimated that the otter was at least 20 feet back in the cavity.

During the following winter a large male otter was trapped within one-quarter mile of this den, and so far as I know, is the last to have been taken in the vicinity. This animal was caught in a log-set by the trapper Reed, listed in Table 1.

It is difficult to arrange the data that I have on delta otters so as to show preference as to habitat. Most of the trappers interviewed, notwithstanding considerable facility in remembering dates and numbers, were indefinite regarding the exact habitat in which they had captured otters. Invariably they were able to recall the name of the lake or swamp in which they had made their heaviest catches, and the years thereof, but few could classify their grounds in terms of deep- or permanent-water swamps, shallow- or winter-spring-water swamps, open lakes, or sluggish streams. The following is the most reliable evaluation of habitat preference that I am able to make from the information at hand, and it is applicable only to original conditions in the delta, as obviously no significant evaluation of habitat preferences can be made after settlement, lumbering, and general human occupancy had forced the otters into less suitable areas. These general habitats are listed in the decending order of preference: 1. Swamp, deep-water, and adjacent or closely connected with large lake. 2. Swamp, deep-water, some distance from large lake. 3. Lake, log-filled, and heavily timbered and shaded. 4. Creek or small river, log-filled, and heavily timbered and shaded. 5. Swamp, shallow-water, and adjacent or closely connected with lake. 6. Lake, large, open, with comparatively few logs and trees. 7. Swamp, shallow-water, some distance from lake. 8. River, large, clear, with comparatively few logs and trees. 9. River, large, muddy, such as the Yazoo even in the early days.

It seems probable that deep-water swamps are preferred because they supply both food and shelter, and also because they are more secluded. The ideal appears to be a deep-water swamp adjacent to a large, log-filled, fish-producing lake, which supplies additional food and abundant water for swimming or play. Nearly all trappers queried were in accord in believing that otters greatly prefer clear to muddy water. As is well known, otters are very mobile and are capable of changing habitats at any time. For this reason the above arrangement perhaps means less than if a more stationary species was involved.

The effect of floods on otters is a point on which I have questioned numerous old-time and modern trappers. In general, they seem to think that high water is of little moment in the life and activities of the species. The most serious influence is the matter of flooded dens, which, if inundated at the time of whelping or shortly after, might have serious consequences. Litters born

in February or early March have a few weeks for growth before the peak of the flood season, which usually comes in April or early May. Juvenile mortality from this cause has never been investigated, but is probably not high because of the animal's superb adaptation to aquatic life. Food, in the form of fish, frogs, and crayfish, might be scattered over a wider area, but still would be amply available. Floods that raise water levels more than 2 or 3 feet undoubtedly flood many dens. New or temporary dens can be found in hollow logs, snags, and stumps, however, although originally only the first two retreats were available. At present, emergency dens are more plentiful, as more hollow logs, attributable to lumbering, occur in the swamps; and hollow cypress and tupelo gum stumps are almost limitless in number. Such stumps and snags average about 8 feet in height, and are filled to varying levels with 10 to 40 years' accumulation of leaves and twigs. Many support young cypress and gum saplings, growing from seed dropped into the cavities, and are overtopped by second growth and defective timber. When floods raise the normal water level 2 or 3 or more feet, there is little doubt of the otter's ability to climb the remaining distance to the top. As temporary refuges, these stumps and snags are undoubtedly satisfactory.

The range of otters may be increased, or at least locally widened, by floods. Several trappers claimed to have trapped otters during floods on logs in water at the time, but as much as one-half mile from permanent water of normal level. These catches were made in ridge stands of oak, red gum, elm, and ash, and, if true, certainly indicate that otter frequent such flooded areas.

The present population of delta otters is not known, but the state of Mississippi is aware of the critical decrease, and happily has given the species full protection during the last several years. As a result, otters in the larger and more remote swamps may be holding their own or even slightly increasing. The total area now having suitable otter environments is small throughout the state, but in spite of all factors making for reduced populations, the largest number of animals, as well as the greatest amount of suitable range, still occurs in the delta region. This is especially true of several counties bordering the Mississippi River.

While the present status of the delta otter is perhaps more encouraging than it was a decade ago, there is no hope of returning the animal to all of its former range, to say nothing of returning it to its former numbers. The encouraging feature is that in every delta county there are swamps, and systems of lakes, creeks, and bayous, of sufficient quality and area to hold a limited otter population. Moreover, through the applications of management, these now empty environments can be improved and made capable of holding a larger otter and general wildlife population than is now their present capacity. And the swamps with a few otters left can by the same process be made to produce a much greater number of animals.

By nature, the otter is not subject to intensive management, as may be applicable to muskrats or whitetail deer. Even in the most favorable of its original habitats the population was comparatively thin. Not subject to crowding, it is perhaps the least stationary of American aquatic fur-bearers. Given a suitable sex ratio, the 3 basic requirements are room, food, and cover. The delta, to a now limited degree, can supply all three.

With these three essentials available over a limited range, which includes most of the areas on which otters can reasonably be expected to be returned, it seems worthwhile to suggest points that would be of value in the rehabilitation of the species, and wildlife in general, in the region. These are as follows:

1. Full protection for remaining otters. This is undoubtedly the most important step at present, and has already been taken by the state. Protection for otters should extend as long as necessary, even if indefinitely; and for other species as present and future studies indicate.

2. Education of the people, especially the large white and negro tenant classes, to appreciate wildlife values. This is a slow and discouraging process, but one of the steps most likely to yield the best future returns. It can be done, as is well illustrated by the notable accomplishments of the Forest Service in regard to fire, and the various health departments in regard to the screening of rural homes.

3. Stream and lake bank protection and restoration. This step need not conflict with the interests of bathing, fishing or general outdoor recreation; indeed, these are parts of the same program. The restoration of delta lakes and streams would be a boon to fishermen; it would improve the resort business as it would make such areas more attractive; and the hunter, trapper, and the aesthetic outdoorsman would share in the profits.

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GEOGRAPHIC DISTRIBUTION OF COLOR PHASES OF THE RED FOX AND BLACK BEAR IN THE PACIFIC NORTHWEST

By Ian McTaggart Cowan

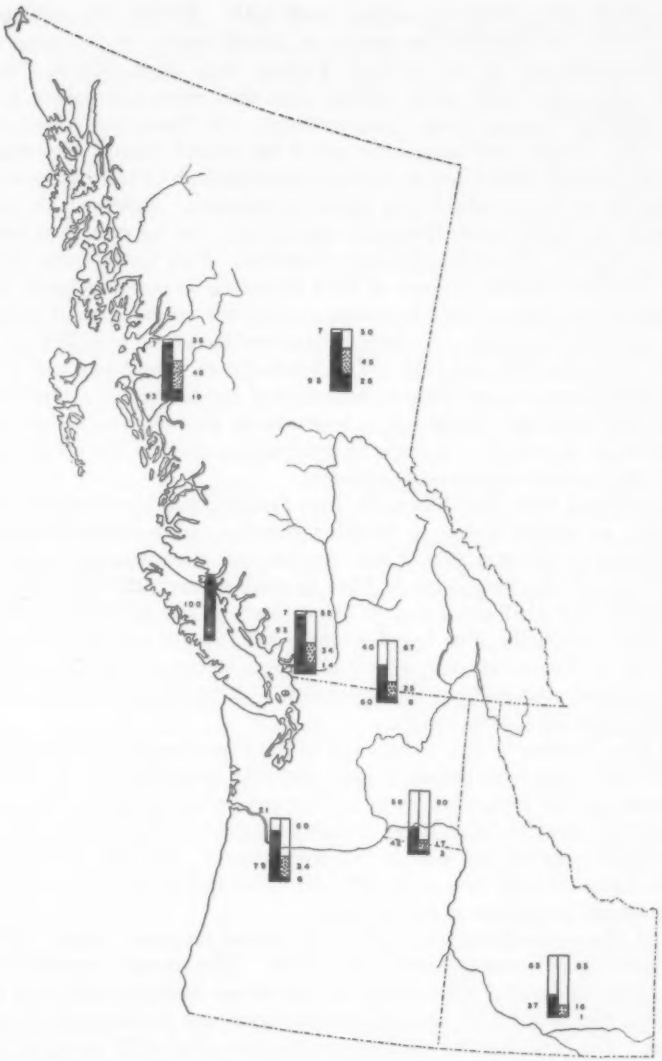
In the Archives of the Province of British Columbia there is a notebook in which James Douglas, then a chief factor of the Hudson's Bay Company and later governor of the Crown Colony, tabulated, year by year, from 1825 to 1857, the furs traded at the various posts and trading districts in the area west of the Rocky Mountains.

Besides the summarized returns from New Caledonia (roughly the area now known as the Omineca District, northern British Columbia), the Columbia District, and the Northern Department, this journal contains detailed figures from Fort Langley at the mouth of the Fraser River, Fort Nisqually on Puget Sound, Fort Simpson on the north coast just south of the Nass River, Fort McLoughlin, now Bella Bella on Denny Island, Fort Rupert on northern Vancouver Island, Fort Victoria at the southern extremity of Vancouver Island, Fort Vancouver near the site of the present city of Vancouver, Washington, Thompson's River, now Kamloops, British Columbia, Fort Colville in north central Washington, Fort Nez Percés near the site of the present town of Wallula, Washington, as well as a statement of the furs collected by the steamship Beaver along the coast of what is now British Columbia, and the results of the Snake River expeditions.

While the fur traded at each of these posts can be taken as representative of the general region in which the post is situated, there was, of course, a certain percentage of furs annually coming to each post from more remote districts. Thus there were skins of fisher, fox, and lynx, traded at Fort Victoria, although these animals do not exist on Vancouver Island. However, the proportion of these furs coming from outside the general region of the fort was apparently small and not sufficient greatly to disturb the returns of a fort as indicative of conditions in its vicinity. In certain cases, such as Fort Vancouver and Fort Langley, situated as they were on main routes of travel to and from the interior, it might be expected that the influence of the country to the east would be more evident. Even here, however, there were a sufficient number of other posts farther inland on the same route of travel to stem the flow of furs from the interior toward the coastal trading establishments.

Because both the black bear and the red fox have color phases sufficiently distinct so that they have always been recorded separately in the fur returns, the figures contained in these tables provide for the first time concrete evidence of certain facts regarding the geographic distribution of the color phases of these animals that have hitherto been suspected, or accepted solely on the basis of field observation.

The black bear, with its various degrees of brown and cinnamon, was found



Map of British Columbia, Washington, Oregon and Idaho, with graphs illustrating behavior of color phases of black bear and red fox. Single column or left hand columnar graphs and figures refer to the black bear; ■ = black phase, □ = brown phase; figures represent percentage of total population contributed by each color phase. Right hand columnar graphs and figures refer to red fox; ■ = black or silver, stippled square = cross, □ = red; figures represent percent of total population contributed by each color phase.

everywhere throughout the region dealt with. Within this wide general distribution are included the ranges of several races. It has been stated elsewhere (Racey, K., and I. McT. Cowan, Ann. Rept. British Columbia Prov. Mus., pp. 15–29, 1935, (1936)) that the brown color phase is much less abundant in some areas than in others. On Vancouver Island, Queen Charlotte Islands, and most if not all of the coastal islands, including also the narrow strip of territory on the mainland of British Columbia immediately adjoining the coast, the brown phase is unknown. Inasmuch as no post drew its fur supply solely from this coastal area, the fur returns at hand do not completely substantiate this last statement. Fort Victoria, Fort Rupert, and Fort McLoughlin, because of their situations on coastal islands, drew a smaller proportion of their furs from outside the coastal area than any of the other trading posts. At these forts a combined total of 3758 bears were traded between 1834 and 1857. The 3 per cent of these bears that were of the brown phase can be taken as indicative of the amount of extraterritorial trade that went on. Inasmuch as brown bears were often to be had within 30 miles of salt water, it is really surprising that more of them did not find their way to these insular establishments.

The returns from Fort Nisqually, Fort Langley, and Fort Simpson, which tapped the coastal region of British Columbia and northern Washington as far east as the east side of the Cascade and coastal ranges, give a fair indication of the conditions in that general region. Here we find Fort Nisqually with 1197 black and 79 brown bears in the period between 1834 and 1852. Similarly, Fort Langley received 3411 black and 261 brown, Fort Simpson, on the north coast, 13,320 black and 960 brown, giving a total for the mainland coast and coastal mountains of 19,228 bears, of which 1300, or roughly 7 per cent, were brown.

At Fort Vancouver the 21 per cent of the bears traded that were of the brown color phase is probably only partially indicative of an increased incidence of the brown phase as one progresses southward. The ease of travel down the Columbia River probably resulted in many more pelts from the interior reaching the coast at this point than was the case farther north, where communication was more difficult. This in turn would tend to raise the apparent proportion of brown bears.

From the semi-arid interior east of the coastal mountain ranges, we have the figures from Kamloops and Fort Colville. The returns from these forts total 1365 blacks and 608 browns at the former between 1826 and 1856; and 3813 blacks and 2871 browns from the latter post during much the same period. The total for the southern interior thus was 8657 bears, of which 3479 or roughly 40 per cent were brown.

Farther east, in the range of the race sometimes recognized as the cinnamon bear, *Ursus americanus cinnamomum*, there occurred an even greater percentage of brown bears. In fact, in the Columbia River region at Fort

Percés, between 1826 and 1852, 2394 bears were recorded, of which 1390 or 58 per cent were of the brown or cinnamon color phase. In the extreme southern and eastern section covered by our data, viz. the Snake River region, it is found that 63 per cent of the bears secured were brown, 37 per cent black; while at the extreme north of British Columbia, as represented by the returns for New Caledonia, but 7 per cent of the 5640 bears taken were brown. Not only is there a pronounced increase in the proportion of black bears from east to west, as 37 per cent in the Rockies, and 100 per cent on the coastal islands of British Columbia, but there is an almost equally pronounced change from south to north, as 37 per cent in southern Idaho, and 93 per cent in New Caledonia.

Had further note of color been kept it would have shown that not only does the proportion of brown to black bears lessen rapidly as the coast is approached, but also that such brown bears as occur on the coast are very much darker than those farther east. Thus a chocolate color replaces the red brown or cinnamon type of coloration so abundant in the Rocky Mountain region. Although not recorded separately in the fur returns, the "blue" color phase, commonly regarded as characteristic of the glacier bear, *Ursus a. emmonsii*, is of scarce but regular occurrence on the coast of British Columbia south at least to Kingcome Inlet. The recognized tendency for insular populations to produce a greater than normal percentage of albinistic individuals further led to the erroneous description of *Ursus kermodei* as a white bear. The resulting publicity led to a selective removal of the albinos, with the result that white individuals are now no more abundant in the range of *kermodei* than elsewhere in British Columbia.

The situation with regard to the red fox (*Vulpes fulva*) with its color phases, the cross and silver or black, is similarly illustrative. In this carnivore we find color intensifying and the incidence of the darker color phases becoming greater more rapidly toward the north than toward the coast.

In the Puget Sound region foxes then as now were not abundant. The combined figures for Fort Nisqually and Fort Langley covering the 30 years from 1827 to 1856 show a total of 233 foxes. Of these, 14 per cent were silver, 34 cross, and 52 red.

On the north coast, as obtained from the returns of Stikine, Fort Simpson, and the steamer Beaver, in roughly the same period, 3867 foxes were traded, of which 19 per cent were silver, 46 cross, and 35 red.

In the interior of British Columbia and north-central Washington, a similar south-north trend of increased pigmentation is manifest. Of 3163 foxes traded at Fort Colville between 1826 and 1853, but 98, or about 3 per cent, were silver, 497 or 16 per cent were cross, and 81 per cent were red. Farther north in the Kamloops district, of 3467 foxes received at Thompson's River post between 1826 and 1857, 409 or 12 per cent were silver, 33 per cent cross, and 55 per cent were red. This trend continued to the northward

and in the returns for New Caledonia, in the northern interior, we find 25 per cent of the 3637 foxes taken between 1825 and 1856 to have been silver, 45 per cent cross, and 30 per cent red.

In the southern Columbia River region, as represented by Fort Nez Percés, of 1597 foxes, 46 or 3 per cent were silver, 17 per cent cross, and 80 per cent red.

The Snake River expeditions tapped the region along that river through eastern Oregon, southern Idaho, Wyoming and even at times penetrated northern Utah. In this Great Basin region, considerably south of any areas previously dealt with, we find an even greater reduction in the occurrence of the silver and cross phases. Of 2464 foxes recorded, only 0.9 per cent were silver, 16 per cent cross, and 83 per cent red.

It is difficult to correlate these figures with present concepts of the distribution of the recognized races of *Vulpes fulva*. However, the above data certainly deny the statement by Merriam (Proc. Wash. Acad. Sci., vol. 2, pp. 661–676, 1900) that the Cascade red fox, (*Vulpes f. cascadensis*) is commonest in the 'black-cross' pelage. Our figures for this race give a combined percentage of silver and cross foxes of 48, as against 52 per cent in the red phase.

The range of the British Columbia red fox (*Vulpes f. abietorum*) seems to produce the greatest percentage of black and cross individuals. These total 70 per cent of the population.

In conclusion, it would seem that in the Pacific northwest there is some parallelism between the incidence of the dark phase in both the black bear and the red fox. In both, the red phase is most numerous to the south and east, and proportionally less so to the north and west. It is possible that further study of the distribution of the races of these two mammals will bring to light some correlation between structural modification and behavior of the color phases.

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STUDIES ON RODENT POPULATIONS IN A FORESTED AREA

By Donald M. Hatfield

During the latter half of the summer of 1937, while located at the Lake Itasca Forestry and Biological Station of the University of Minnesota, I secured a series of trapping records in several of the forest types represented in the vicinity of the Station. At an earlier date, while I was collecting small mammals at the Cloquet Forest Experiment Station of the University, located in Carlton County, attention had been called to the problem of habitat preference of the various species of rodents. There it was found that, in general, *Peromyscus maniculatus gracilis* is more frequently represented in open upland areas, and *Clethrionomys gapperi gapperi* occurs in larger numbers along the borders of spruce-balsam and tamarack swamps. It was with the hope of determining more exactly the habitat preferences of these genera that the work at Itasca was begun.

The project was carried on from August 9 through September 4, a total of 25 days, and consisted in the establishment of "permanent" quadrats, each set with 25 mouse traps of the museum special type. The traps were situated at 6 foot intervals; each quadrat was thus 24 x 24 feet in dimension. These quadrats, hereinafter referred to as plots, were located in four of the commoner forest types to be found in the vicinity of Lake Itasca, Clearwater County, Minnesota—jackpine (*Pinus Banksiana*), trembling aspen (*Populus tremuloides*), paper birch (*Betula papyrifera*) and spruce-balsam (*Picea canadensis, Picea mariana, Abies balsamea*).

Seven plots were set out and numbered thus: Plot 1, in jackpine of even age and of from 6 to 8 inches in diameter; plot 2, in open aspen of varying age (5 to 15 inches in diameter); plot 3, in even-aged aspen of from 8 to 10 inches in diameter; plot 4, in a spruce-balsam swamp (head of Floating Bog Bay); plot 5, in even-aged birch; plot 6, in the same locality as plot 4, although about 200 yards distant from the latter; and plot 7, in open jackpine of varying age. Plots 1, 2, 3, and 4 functioned for 15 days; plots 5, 6 and 7 were worked for a period of but 10 days. Thus, the former were active from August 9 through August 25; the latter, from August 26 through September 4.

On these plots were trapped 110 mammals during the entire period of 25 days. By far the greatest number of these were *Peromyscus maniculatus*, as might be expected. The actual numbers of each species taken follow: *Peromyscus maniculatus gracilis* and *P. leucopus noveboracensis*, 82; *Clethrionomys gapperi gapperi*, 16; *Zapus hudsonius hudsonius*, 9; *Blarina brevicauda brevicauda*, 1; and *Glaucomys volans volans*, 2.

With a view toward determining the efficiency of the plots set up in this

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work, records were kept of the particular traps in which the mice were caught. Without presenting here the rather lengthy tables resulting from the consideration of these data, suffice it to say that in open plots, with sparse ground cover, 70 to 80 per cent of the mice were caught in those traps bordering the plots, while in plot 2, with relatively dense cover, only 53 per cent of the mice were caught in the outer traps. The significance of this difference, if any, may possibly be that the traps are more easily seen by the mice in open areas, and a mouse, coming upon the plot, would be more liable to be captured in a trap seen first (i.e., one of those bordering the plot).

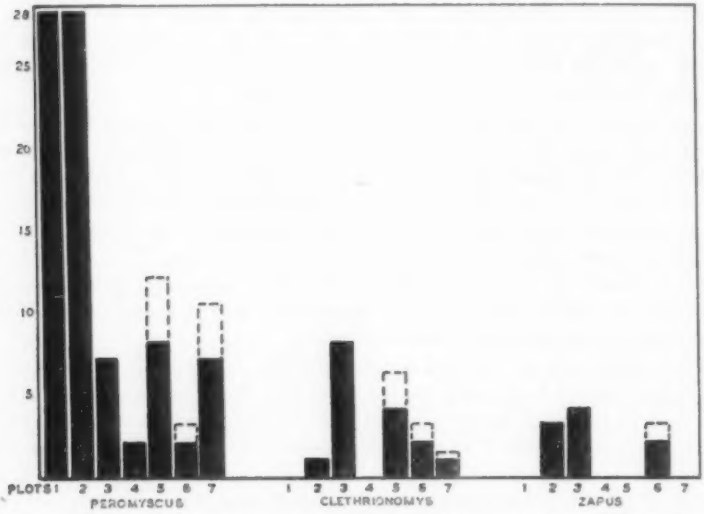

FIG. 1. Histogram showing numbers of mice caught on each plot. Plots 5, 6, and 7, corrected to 15 days.

The relative numbers of the three principal species taken on each plot are shown in figure 1. It will be noted that, even though the total catches on plots 5, 6 and 7 are corrected to 15 days, plots 1 and 2 still outstrip all the others with regard to *Peromyscus*. Reasons for this are not entirely clear at present, although the factors operating in favor of *Peromyscus* in each instance would seem to be different. With plot 1, it might be postulated that the relative lack of ground cover would reduce the competition offered by such species as *Clethrionomys gapperi* and *Zapus hudsonius*, more dependent on relatively heavy ground cover. With plot 2, on the other hand, it seems probable that the *Clethrionomys* and *Zapus* do not enter into serious competi-

tion with the *Peromyscus* because of the relative abundance of food and cover available.

It may well be pointed out here that there seems to be some correlation between the numbers of *Peromyscus* caught and the species of plants comprising the vegetational complex on the various plots. It was noted that plots 1 and 2, on which mice of this genus were most numerous, were similar in that they both bore representatives of the following species of plants in greater or lesser abundance: *Clintonia borealis, Maianthemum canadense, Diervilla Lonicera, Rubus pubescens, Vaccinium pennsylvanicum* and *Aster macrophyllus*. All of these, except possibly the ubiquitous *Aster*, bear fruits which are game foods of some value, and possibly form a major portion of the diet of this mouse.

Consideration of the plants found on other plots seems to lend more weight to this possibility. It is found that plots 5 and 7, upon which the next greatest numbers of *Peromyscus* were obtained, each have 4 of the 6 plant species mentioned above, while plot 3 has 2 and plot 4, 1. Although this is, admittedly, too small a sample to allow the drawing of any general conclusions, and although numerous other factors are undoubtedly involved, the closeness of the correlation leads one to suspect that there is here represented something more than mere coincidence.

I have had occasion to note, at various times and localities, that there is often a definite correlation between the total catch of mice for any one day and the minimum temperature prevailing on the same day. As pointed out at earlier date (Hatfield, 1936), mice of some species seem less active on cold nights than on warm nights. Figure 2 seems to indicate something of this correlation with regard to *Peromyscus*. It will be noted that, on August 11, 12 and 13, there is a "low" in the numbers of mice trapped and a corresponding decline in temperature. This may indicate that the mice are not foraging to such an extent on cold nights as on warm nights. The fact that, on August 14, there is an abrupt rise in minimum temperature and a corresponding abrupt increase in number of mice caught, would seem to strengthen this hypothesis, as would the increase recorded on August 23.

The character of the ground cover on the area considered above practically requires that the mice situated therein forage principally at night rather than during the day. The reference to density of cover on plot 2, mentioned previously, is made only in comparison with plot 1; it is not to be assumed that this ground cover was as dense as that formed by, for instance, various of the native grasses. On the areas under consideration in the present study there is too little ground cover to conceal satisfactorily much supersurface rodent activity during the day. Hence, nocturnal temperatures appear to be the critical ones.

It has been pointed out by various authors that there is an appreciable difference between the rhythmic foraging tendency in *Peromyscus* and that

in *Microtus*. The experiments of Johnson (1926) indicated that, normally, *Peromyscus* is chiefly nocturnal, while Hamilton (1937) pointed out that *Microtus* is most active during the day. It would appear that cover density may be one of the principal factors in the foraging activity of each form. Thus, white-footed mice, generally limited to habitats offering less concealment, and of habits that do not allow of general feeding in concealed situations, forage most actively at night, while meadow mice, taking advantage of the greater concealment offered by the dense cover of grasses generally forming the chief vegetational constituent of their habitat, forage at all hours, but chiefly during the day. It should be noted, however, that the experiments of Behney (1936) seem to indicate that, with *Peromyscus leucopus noveboracensis*, dense cover, as provided by snow, may release the mice from their customarily restricted nocturnal foraging period, in which event they too may forage at all hours.

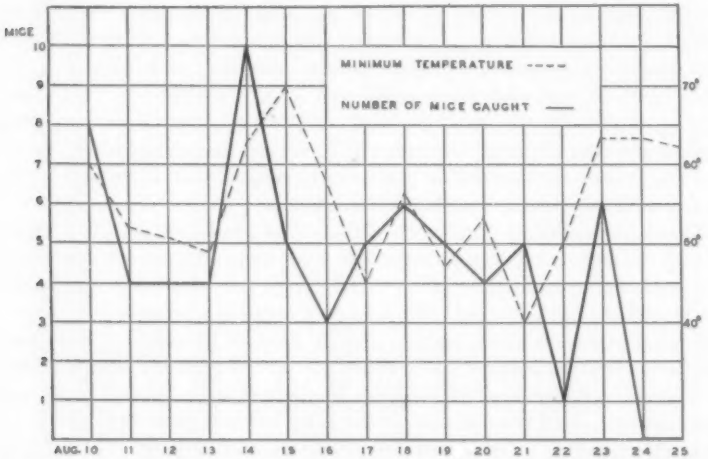

FIG. 2. Comparison of catches of *Peromyscus* with minimum temperature, August 10–25.

Hamilton (op. cit., p. 259) remarked that "Density of cover seems to play little or no part in the movements of voles". In support of this claim he pointed to the fact that, in recently mowed areas, the mice maintained their customary daytime cycle. Incidental live trapping operations carried on at the University of Minnesota have indicated that, in open areas with comparatively thin ground cover, more *Microtus* are caught at night than during the day, while the reverse is true in areas supporting a dense ground cover. Also, I have noted, with a different species (*Microtus californicus*),

inhabited burrows on well-trimmed fairways of golf courses, where concealment above ground is negligible; hence there the mice were forced to do most of their foraging nocturnally. This would seem to suggest that meadow mice, active "at all hours" (Hamilton, 1937a), are able to adjust themselves to various habitat conditions and that the rhythmic activity of these rodents is governed at least to some extent by available cover.

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BATS IN THE STATE OF WASHINGTON

BY WALTER W. DALQUEST

The "Provisional List of Land Mammals of the State of Washington," by Walter P. Taylor and W. T. Shaw, for 8 years has remained the only available check list of the bats in Washington. Since the issuance of this list collectors have made substantial extensions of the ranges of 9 of the 18 forms found in the state. There has also been one change in nomenclature. It was therefore thought advisable to prepare a new list, rather than to amend the old.

Much of the material used is in my personal collection. I am indebted to Dr. Erma Gunther and Mrs. Martha Flahaut for use of specimens in the State Museum. Other records are from the Murrelet, journal of the Pacific Northwest Bird and Mammal Society.

Myotis lucifugus alascensis. Alaska brown bat.—From the eastern base of the Cascade range, west to the Pacific Ocean, and in the Blue Mountains in the southeastern corner of the state.

Myotis lucifugus carissima. Yellowstone bat.—Scattered records from eastern Washington in Transition and Upper Sonoran zones, except in the Blue Mountains. Previously recorded only from Stehikin, north end of Lake Chelan. I have specimens from the south end of Lake Chelan, Newport, Pend d'Oreille County, and Vantage, Grant County.

Myotis yumanensis sociabilis. Tejon bat.—Recorded from Chelan,

Stehikin, and Wallula; probably of general distribution throughout eastern part of state.

Myotis yumanensis saturatus. Miller bat.—From the eastern base of the Cascade range, west to the Pacific Ocean.

Myotis keenii keenii. Keen bat.—Olympic Peninsula only.

Myotis evotis evotis. Little big-eared bat.—The southeastern corner of the state (Godman Springs, Bartholomew, South Touchet); the Cascades (Martin, Easton); and the west side lowlands (Puget Sound, Seattle). The Seattle specimen, in the State Museum, is the seventh locality record in the state and may be considered as topotypical.

Myotis thysanodes thysanodes. Fringed bat.—Southeastern part of the state only. This species was previously known only from Anatone. Eight specimens are in the State Museum, one from Dayton and the others from three localities in the Blue Mountains.

Myotis volans longicrus. Northwestern long-legged bat.—From the eastern base of the Cascades west to the Pacific; also the Blue Mountains in the southeastern corner of the State.

Myotis volans interior. Interior long-legged bat.—Recorded only from Anatone, in the extreme southeastern corner of the State.

Myotis californicus californicus. Little California bat.—Generally distributed in Upper Sonoran Zone of eastern part, southerly.

Myotis californicus caurinus. Northwest coast bat.—Transition Zone of entire state.

Myotis subulatus melanorhinus. Black-nosed bat.—Upper Sonoran Zone of the eastern part of the state. Previously recorded only along the extreme southern border of the state. I have specimens from Vantage, Grant County, 3 miles west of Vantage in Kittitas County, Wenatchee, Chelan County, Moses Coulee, Douglass County, and the Grand Coulee, 3 miles below the dam.

Lasionycteris noctivigans. Silver-haired bat.—Transition and Canadian zones of entire state. Not yet found on the Olympic Peninsula but probably present. Recorded as common at Seattle (Dalquest, Murrelet, vol. 17, p. 56, 1936).

Pipistrellus hesperus hesperus. Canyon bat.—In the Upper Sonoran Zone along the extreme southern border of the state and north along the Columbia River at least to Vantage, Grant County. I have 2 specimens from Vantage, a northern record for this southern species.

Eptesicus fuscus subsp. Big brown bat.—Transition Zone of the entire state. Not yet taken from the Olympic Peninsula. In 1929 only one record of this bat was known from west of the Cascades. Since then an increasing number seems to have been noted (M. Flahaut, Murrelet, vol. 12, p. 56; vol. 14, p. 77). In 1936 and 1937 it was abundant near Seattle. A series of big brown bats collected in the Puyallup Valley by Ford Dicks was re-

ferred to the subspecies *bernardinus*, Rhoads, by G. S. Miller, Jr. (Murrelet, vol. 16, p. 41.). Vernon Bailey (1936, p. 380) listed specimens from both sides of the Cascades in Oregon as *Eptesicus fuscus fuscus*. There may be two races in Washington, but I believe that a great deal more material must be collected before anything definite can be decided.

Nycteris cinerea. Hoary bat.—Recorded practically throughout the state. D. E. Brown quoted Leo K. Couch (Murrelet, vol. 16, p. 72), in saying "Actual records for this species show that it comes down the coast in a short fall migration, and that it migrates north in the spring through eastern Washington." In 1929 this species was known only from eastern Washington. Since then a number of west side records have been made. (M. Flahaut, Murrelet, vol. 14, p. 77; Couch, Murrelet, vol. 15, p. 25; D. E. Brown, Murrelet, vol. 16, p. 72). Four other specimens are in the State Museum.

Corynorhinus rafinesquii townsendii. Townsend lump-nosed bat.—Scattered Transition Zone records. West of the Cascades from Fort Vancouver (type locality), north at least to Puyallup (Ford Dicks); also the east slope of the Cascades (Boulder Cave, Kittitas County) and the Okanogan highlands (15 miles east of Tonasket, Okanogan County). The Taylor and Shaw check list gave only Boulder Cave, neglecting the fact that the type locality is in Washington. The specimens (7) from the Okanogan highlands constitute a northern record for the state.

Antrozous pallidus cantwellii. Big gray bat.—The extreme southern border of the state, in Upper Sonoran Zone and north along the Columbia to Wenatchee. The specimen from Wenatchee (Dalquest, Murrelet, vol. 17, p. 56) constitutes a northern record for this species in the state, although there is one record for British Columbia (Kenneth Racey, Murrelet, vol. 14, p. 18).

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PNEUMONIA IN ROCKY MOUNTAIN BIGHORN SHEEP

By Hadleigh Marsh

For the past 13 years, reports have come to the Montana veterinary laboratories in Helena and Bozeman of disease losses in the Rocky Mountain bighorn sheep. The first investigation to determine the cause of the losses was made in 1924 in the Sun River Game Preserve, and since that time several investigations have been made in that region and in Glacier National Park, Yellowstone National Park, and the National Bison Range. The work has been done by the Montana Livestock Sanitary Board and the Montana Veterinary Research Laboratory, in cooperation with the U. S. Bureau of Animal Industry, the National Park Service, the U. S. Forest Service, and the Montana Fish and Game Commission. Recently, an independent study of the bighorn losses in Glacier National Park has been made by Wildlife Technician R. M. Bond, of the National Park Service, in which the Montana Veterinary Research Laboratory participated in a consulting capacity.

These investigations show that the losses have been caused by respiratory diseases of two types. The condition that has been the most prevalent has been a somewhat chronic pneumonia that has caused death principally in mature sheep. The second type of disease has been observed on the National Bison Range, where an acute pneumonia has killed lambs at the age of two to three months.

VERMINOUS PNEUMONIA

During the winter of 1924 and 1925, there was a very considerable loss of bighorn sheep in the Sun River Canyon. Field investigations of this condition were made by the state game warden, the supervisor of the national forest, and Dr. B. O. Fisher of the Montana Livestock Sanitary Board. Of a band of about 100 sheep, at least 15 were known to have died. Dr. Fisher made a field diagnosis of pneumonia. The heart and lungs of two old ewes, and the entire carcass of a two-year-old ram that was shot for examination, were sent to the laboratory of the Livestock Sanitary Board at Helena, where bacteriological and histological examinations were made. Again in November, 1927, losses were observed among the Sun River bighorns, and the entire carcass of a lamb that had died was sent to the Helena laboratory for examination.

In January, 1927, at the request of the superintendent of Glacier National Park, an investigation of bighorn losses was made by Marsh, representing the Livestock Sanitary Board, and Dr. N. G. Cobbett, of the U. S. Bureau of Animal Industry. Between December 25, 1926, and January 11, 1927, 26 sheep had died out of the Many Glaciers band, which was estimated to

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comprise about 150 animals. Of these 26 animals, 7 were mature rams, 14 were mature ewes, and 5 were yearlings.

The environmental conditions of this band of sheep were of interest. Since 1919, the Many Glaciers band had been fed hay each winter. This was the only place in the Park where sheep were being fed, and it was the only place where losses were known to occur. The feed ground was near the Many Glaciers chalets, the hay being placed in racks.

At the time of the investigation, two days were spent studying about 40 sheep that were on the feed ground and stayed near the buildings, many of them bedding down beneath the porches of the chalets. There were several sick animals in the lot, and 3 of the weakest sheep—an old ram, an old ewe, and a lamb—were shot. Autopsies were made immediately and tissues taken to the laboratory.

During the winter of 1936 and 1937, losses again occurred in the Many Glaciers band, and an investigation was made by Dr. R. M. Bond, Wildlife Technician of the National Park Service. An autopsy on one of the sheep was made jointly by Drs. Bond and Marsh at the Veterinary Research Laboratory at Bozeman. The conditions under which losses occurred were similar to those observed in 1927, and the pathological findings were the same.

During the winter of 1927 and 1928, lung specimens were received from 4 sheep in Yellowstone National Park, with no significant history. Pathological and bacteriological examinations were made. Three of these animals were mature sheep that showed lesions of the same respiratory disease found in the Glacier Park sheep. Further investigations were made in Yellowstone Park in 1931 and again in 1934. In May, 1931, an autopsy was performed on an old ram that was killed for study by W. M. Rush of the U. S. Biological Survey. This ram had been under observation all winter as a sick animal. Material was brought to the laboratory for bacteriological study, and parasites were sent for identification to the Zoological Division of the U. S. Bureau of Animal Industry.

In November, 1934, it was reported by F. W. Childs, of the National Park Service, that several sheep in a band near Mammoth Hot Springs were coughing. On November 8 and 9, Marsh, with Mr. Childs and H. W. Mills, zoologist in the Park Service, made observations on these sheep. About 85 sheep running in 4 small bands were observed. They were running on the bench east of the Gardiner River on range that had been seriously damaged by dry weather and badly overgrazed by sheep, antelope, deer, and elk. Several of the sheep were in poor condition, and 8 of them, including one lamb, were seen coughing after exertion. A ewe from this group was shot, and an autopsy was performed. Parasite specimens were sent to the Zoological Division of the U. S. Bureau of Animal Industry for identification, and material was brought to Bozeman for bacteriological examination.

Symptoms.—The same symptoms were observed in all the investigations made in Glacier Park, Yellowstone Park, and Sun River. About 10 per cent of the sheep under observation were noticeably thin and weak. These animals all had a loose, bronchial cough, a symptom that was noticed also in other sheep apparently in good condition. The paroxysms of coughing usually occurred after the sheep had been disturbed. In the resting animals no abnormality of respiration could be observed, but dyspnoea developed in some cases after exertion. The worst cases showed loss of flesh, harsh coat, disinclination to move or eat, and weakness, evidenced by a somewhat uncertain gait and a tendency to lie down.

Pathology.—Autopsies have been performed on 8 sheep in six investigations in Glacier Park, Yellowstone Park, and Sun River. In addition to the material obtained from these autopsies, 6 sets of lungs were received for examination at the Helena laboratory from sheep in Sun River Canyon and Yellowstone Park. Of the 8 complete autopsies, 7 were made on animals shot for the purpose of study, and 5 were made at the place where the sheep were killed, either immediately after shooting or within a few hours.

No significant pathological condition was observed in any of the sheep except in the thoracic cavity. Fourteen sets of lungs were available for examination, and the same general pathological condition was found in all cases. There was a subacute, or chronic, bronchopneumonia. The apical and cardiac lobes of the lungs were consolidated in all cases, and portions of the diaphragmatic lobes were also consolidated. There was usually some pleuritis with adhesions. There were one or more abscesses containing a creamy pus with greenish color. Mucopurulent exudate was present in the bronchi, particularly in the consolidated regions. There was congestion throughout the lungs. The consolidated areas showed a mottled appearance, with small, gray nodules a few millimeters in diameter set in a dark red background. There were usually several firm nodules in the lung tissue in the posterior portions of the diaphragmatic lobes. In one case there was pericarditis, the pleura was hemorrhagic, and the thoracic cavity contained a large quantity of bloody seropurulent fluid. In some cases the mediastinal lymph nodes showed some congestion.

Material from 7 lungs was sectioned and examined histologically. The histological picture was that of a bronchopneumonia. There was congestion of blood-vessels and alveolar capillaries. There was infiltration of monocytes and lymphocytes beneath the bronchial epithelium in places, and degeneration and desquamation of bronchial epithelium was found quite constantly. Some sections showed an exudate of leucocytes and erythrocytes on the bronchial mucosa. There was infiltration of monocytes into the alveolar walls, and in some consolidated areas the lumina of the alveoli were obliterated by thickening of the alveolar walls due to engorgement of capillaries and cellular infiltration. In some areas there was exudate

into the alveoli and bronchioles containing leucocytes and epithelial cells. Many bronchioles were plugged with leucocytes. There was peribronchial and perivascular infiltration of lymphocytes and monocytes. In sections from 3 animals nematode larvae were seen in areas of exudation into the alveoli and in the bronchi.

Parasitology.—On gross examination no parasites were found in the lungs. In the Glacier Park investigation, made in 1927, it was found that microscopic examination of bronchial exudate showed large numbers of the larvae of a lungworm that later was identified by the Zoological Division of the U. S. Bureau of Animal Industry as *Protostrongylus stilesi.* In the smaller bronchioles were many eggs of this species. Since that time the larvae of this lungworm have been detected in abundance in the bronchial exudate of all lungs examined. It has been very difficult to find any adults of this nematode and there have been only a very few discovered in all the lungs examined. More adults were found in a sheep killed in November than in those examined in the winter and spring.

In one autopsy a careful examination of the intestinal tract was made, the contents being washed out and examined. *Ostertagia marshalli* was found in considerable numbers in the abomasum. The small intestine was free from worms. One *Cysticercus tenuicollis* was seen on the mesentery.

Bacteriology.—In 8 cases tissues have been received at the laboratory in condition that rendered bacteriological examination possible. The bacteriological findings have been very similar in all cases examined. Direct smears from bronchial exudate, abscesses, and cut surface of lung tissue have shown the predominant organism to be *Corynebacterium pyogenes.* Cultures from bronchial exudate and cut surface of lung tissue have developed *C. pyogenes* and *Pasteurella.* Cultures from the heart blood have developed *C. pyogenes* in pure culture in 4 of 5 hearts cultured. In the fifth case no bacteria developed in heart blood cultures. In one case in which there was pericarditis, *C. pyogenes* developed pure in cultures from the pericardial fluid and the heart blood.

PASTEURELLOSIS IN LAMBS

On the National Bison Range in western Montana, losses of bighorn lambs have been reported by Dr. R. S. Norton, who is in charge of the Range, as occurring each summer in July and August, when the lambs are two to three months old.

On August 11, 1933, Dr. Norton brought to the laboratory at Bozeman a lamb that had died at 8:30 P.M. on August 10. This lamb had been observed to be sick for 4 days. The autopsy was made at 9:00 A.M. on August 11. The only pathological lesions found were in the lungs. The left lung was practically normal. The anterior portion of the right lung, including the apical and cardiac lobes and the anterior portion of the diaphragmatic

lobe, was pneumonic, with adhesions to the pericardium and the parietal pleura. This entire region was completely consolidated. There was a suppurative condition, without abscess formation, but with much necrosis of lung tissue. There was an excess of pericardial fluid. A careful search for lungworms, either adults or larvae, showed none present.

Smears from the cut surface of the pneumonic lung showed *C. pyogenes* present as the predominant organism, and also *Pasteurella*. Cultures from the heart blood developed *Pasteurella*, with *C. pyogenes* also present. Cultures from the lung and from the pericardium developed *Pasteurella* and *C. pyogenes*. On plates seeded directly from the lung tissue, *C. pyogenes* was predominant, while *Pasteurella* was in the majority on plates seeded from the pericardial fluid.

On July 11, 1934, the heart and lungs of a lamb were received at the laboratory. In this case the left lung was pneumonic, with complete consolidation of the apical and cardiac lobes and a portion of the diaphragmatic lobe. Cultures from the lungs developed *C. pyogenes* and *Pasteurella*, while the heart cultures developed pure *Pasteurella*. This lung also was free from parasites.

DISCUSSION

Our interpretation of the findings in the principal group of cases of pneumonia in bighorn sheep is that the primary etiological factor in this disease is the infestation with the lungworm *Protostrongylus stilesi*, with secondary bacterial invasion. The organism principally involved is the diphtheroid *Corynebacterium pyogenes*, although a *Pasteurella* is constantly present in the diseased lungs.

As disease is generally the result of several factors, the question arises as to what are the factors contributing to the invasion of the lungs by parasites and bacteria. The life history of lungworms of the genus *Protostrongylus* involves an intermediate host. The larvae develop from the eggs in the lung of the sheep and are passed out with discharges from the respiratory tract and in the feces. The larvae then invade certain species of land snails with flat spiral shells, in which they undergo changes, and the cycle is completed by the ingestion of the snail by sheep, and the development of the worm to maturity in the lung of the sheep. If this be the life cycle of *Protostrongylus stilesi*, the infestation of the sheep must occur during the summer months.

When the sheep are on the high summer range, the environmental conditions in all the areas where the losses have been observed are apparently normal. There seems to be no crowding of wild animals on the summer range and no overgrazing. Therefore there would seem to be no reason for concentration of parasites and heavy infestations as far as the summer range is concerned.

It has been observed, however, that the sheep move down from the higher

ranges quite early, having been seen on their fall range as early as September. As the normal winter range of former years is not available because of the settlement of the lower country by man, the areas occupied in the fall are also grazed all during the winter. In Yellowstone Park this fall and winter range area is heavily grazed by elk, deer, antelope, and sheep. In some seasons the temperature is high enough in September, October, and November to permit of the completion of the life cycle of the lungworm through the infested snail. Under these conditions it seems very probable that the lungworm infestation might become heavier than if the sheep had free access to sufficient fall and winter range. It is also evident that on an overgrazed and relatively crowded range there is greatly increased opportunity for the transmission of the secondary bacterial invaders from one sheep to another.

The losses in Glacier Park have been observed only in the Many Glaciers band, which has been fed hay each winter. In this instance the sheep have begun to concentrate on the winter feeding ground as early as September, when conditions are frequently favorable for transmission of the lungworm through the snail. During the winter, when hay is being fed, conditions are ideal for the transmission of the bacterial infection.

It seems probable, then, that the lack of normal winter range, causing crowding and overgrazing on the fall and spring range, combined with feeding in the case of the Glacier Park sheep, are factors in the development of clinical parasitism and secondary bacterial pneumonia in the bighorn sheep.

It has been suggested that the use of bighorn range by domestic sheep may have resulted in the transmission of lungworms from domestic sheep to wild sheep. This idea seems untenable, as the lungworm occurring in bighorns has been described as a different species of *Protostrongylus* from that found in domestic sheep. In Montana, we have never found any species of *Protostrongylus* in domestic sheep.

The losses from pneumonia in young lambs on the National Bison Range are of a different type from those discussed above in older sheep. Parasites are not involved in these cases, and the pneumonia is of an acute type. Our findings in the only two cases in which bacteriological and histological work was done indicate that the pneumonia is primarily due to invasion by a *Pasteurella*, with *C. pyogenes* as a secondary invader.

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BREEDING RECORDS OF PACIFIC COAST POCKET GOPHERS

By Theo. H. Scheffer

By way of introduction and general discussion, it may be said that a study of the program evolved by a burrowing rodent for the continuation of its kind presents special difficulties. Some of these may be solved by patient research; some leave us groping for approximate knowledge. The domestic relations of a pocket gopher are its own affairs, else we might seek to disarrange them to fit certain biological theories.

To begin with, a gopher finds its life and its living in underground seclusion; its home nest and food stores in the deeper burrows; its mate wherever the opposite sex may be encountered when the green is on the grass roots; and its subsistence in the mines it digs under the herbage and fills again when the pay streak is exhausted.

Then again, gophers do not take kindly to human manipulation in an attempt to arrange their domestic affairs. We may trap them alive and uninjured, keep them for some time in captivity, perhaps rear them to maturity when born in a cage; but so far as my knowledge and experience goes, we have not secured a pre-arranged mating from which to arrive at the exact or the average period of gestation. However, from a long series of field observations through many years and with several species, we are satisfied to let the matter of gestation go at approximately a lunar month, possibly a little less under favorable conditions. What matters the day or the hour, when these factors are likely to vary with previous lactation, or with feast or famine in food supply. We do know that certain stresses of food relations or other untoward physical difficulties will cause resorption of one or more of the embryos already on their way to separate existence.

Other grounds for uncertainty, in arriving at the exact support given the program of continuing the race by any particular group of gophers, is found in the greater seclusion of the females in advanced pregnancy. Postmortem studies being the main reliance in securing breeding data, we have roughly divided the stages of pregnancy into early, medium, and advanced, according to the degree of development of the fetal sac as shown by accurate measurements. Following this line of investigation, it is found that there are many more females taken in early than in medium pregnancy, and three times as many as in the advanced stage. Manifestly, the more gravid females stay by their nests and the food stores, rather than blunder around looking for traps. And just as manifestly one cannot often dig for them on unknown leads, to depths of several feet in most soils.

Postmortem study of the gopher is not entirely an open book, even to the initiated and experienced. In passing, it may be said that much may be learned from examination of the males, as well as the females. Growth and development to maturity may easily be read in the male, as also recession

from seasonal breeding condition after the cycle of the spring mating. For the gopher falls into the group of rodents that, in temperate climes at least, suffers a reduction of the sexual organs to a condition of sterility in late spring or early summer, to remain so until the passing of the ensuing winter. In southern California, where broods of the gopher are continuous, at least from October to June, inclusive, it is difficult to determine always in field examinations whether one is dealing with a well-grown but immature male, or an adult that may have receded from breeding status to a rest period.

Reproductive intentions of the female gopher are read, postmortem, mainly in the horns of the uterus, which will show not only numbers and approximate age of a brood but scars indicating similar data for a litter already in the nest, or perhaps already at the age of dispersal. Accurate observation shows that such scars persist for at least two weeks. But in the northern species there is a variable number of females that go through the spring season without mating, depending on isolation of individual burrows, or proximity of these to each other in the semblance of a colony. Encounter of the sexes, in my observations, is usually if not always in the burrows. In the height of the mating season one may take numbers of pairs in the burrows, each pair at a double setting of the traps, one trap facing each way. Also daylight and flashlight observations in the field at such times have not revealed any gophers moving about above ground. Probably such excursions, not infrequently noted, are confined to short foraging trips, in season, or to dispersal of the growing young.

There has been considerable discussion as to whether or not a female gopher may, in the more northern parts of our country, produce two broods in a season. My observations do not indicate a single case of a second brood. In early spring the males develop sexually somewhat in advance of seasonal maturity in the females. Then, from the time of observed mating activity, through earliest noted pregnancy to birth of the young and subsequent lactation, there are but a few weeks of sexual vigor, too few to permit rearing of a second brood under average seasonal conditions. It is true that the period of reproduction in the more northern species is prolonged beyond that of the weeks allotted by nature to *Citellus*, or *Aplodontia*, or *Scapanus*, in the same general regions. But in the case of the gopher the chances for a meeting of the sexes are not so favorable as with any one of the other groups mentioned. Scattered birth of the broods helps to support this conclusion.

The gopher, however, is apparently an opportunist in the matter of continuing the race. Confining ourselves to studies of 5 species of *Thomomys* in the 3 Pacific coast states—*douglasii* on the Olympia prairies and *fuscus* in eastern Washington; *bulbivorus* in the Willamette Valley, Oregon; *bottae* in the San Gabriel Valley and *perpallidus* in the Imperial Valley, California—it is found that the more favorable conditions, perhaps brought about by

TABLE I

TRAPPING RECORDS, WITH BREEDING DATA

TRAPPING DATES	♂	♀	JUV.	PREGNANCY				
				Early	Medium	Advanced	Showing fetal scars	
Feb. 12–14	23	31	0	2	0	0	0	*Thomomys fuscus*, Kennewick, Wash.
March 6–7	24	26	0	0	1	0	0	
April 2–3	35	8	8	2	0	0	2	Number males taken.. 105
Apr. 28–30	11	7	32	1	0	2	0	Number females..... 76
May 26–28	11	4	25	0	0	0	0	Average litter..... 6.3
July 28–30	1	0	7	0	0	0	0	
February 15	10	5	0	0	0	0	0	*Thomomys bulbivorus*, Corvallis, Oregon
March 15	12	8	0	0	0	0	0	
April 12	12	9	0	1	1	0	0	Number males taken.. 93
May 5	11	10	0	0	2	1	3	Number females..... 81
October 20	48	49	22	0	0	0	0	Average litter..... 4.2
March 18–20	24	27	0	2	0	1	0	*Thomomys douglasii yelmensis*, Olympia, Wash.
Apr. 15–17	27	27	0	2	2	2	5	
May 13–15	31	22	17	2	0	1	5	Number males taken.. 313
June 10–12	18	16	21	0	0	0	2	Number females..... 312
Nov. 6	6	6	0	0	0	0	0	Average litter..... 5
January 4	3	4	0	0	0	0	0	
February 8	5	3	0	0	0	0	0	
March 1	5	8	0	0	0	0	0	
March 19–20	14	14	0	0	0	0	0	
February 20	8	8	0	0	0	0	0	Note: Trapping this season mainly on virgin prairie
March 7	9	15	0	0	0	0	0	
March 21	6	12	0	0	0	0	0	
April 4	16	14	0	2	2	0	0	*Three pairs taken (prairie)
April 19	16	11	0	3	0	1	0	
May 2	8	12	0	3	2	1	2	
May 18	20	18	5	0	0	0	13	Sex organs, male, retrograde
June 2	17	16	5	0	2	0	0	Dispersal of young in progress
June 15	13	9	3	0	0	1	0	
July 15	5	8	9	0	0	0	0	
November 7	4	3	9	0	0	0	0	
March 24–28	14	17	0	1	2	0	0	*Five pairs taken (prairie)
May 4–5	13	14	0	6	0	0	0	*Two pairs taken (clover)
May 11–12	13	15	7	2	0	0	?	Sex organs, male, retrograde
May 23–26	18	13	26	3	1	1	?	Dispersal of young in progress

* Male and female gopher taken same night, same spot, same setting; one trap facing each way in main run.

introduced food supply, have greatly accelerated reproduction. In the two valleys of southern California just mentioned, the ditch and the plow have brought in perennially green subsistence for the gopher, particularly alfalfa. So now there is a considerable percentage of field pregnancy among the gophers there, at least from early October to middle June. We still lack data on midsummer breeding.

Taking as a basis for comparison, therefore, the average litter of the single-brooded northern gophers of the Pacific Coast, it may be said that *per-*

TABLE II

TRAPPING RECORDS, WITH BREEDING DATA

TRAPPING DATES	♂	♀	JUV.	PREGNANCY					
				Early	Medium	Advanced	Showing fetal scars	Percent of field pregnancy	
Oct. 13–16	18	18	14	3	3	1	0	39%	*Thomomys bottae*, El Monte, Calif.
Nov. 10–12	10	26	16	5	3	2	7	38.4%	
Dec. 6–8	11	40	12	12	7	1	6	50%	Males taken 143
Dec. 22–24	11	27	13	5	3	2	6	37%	Females taken 289
Jan. 22–23	10	29	17	1	3	2	4	20.7%	Average litter 5.85
Feb. 4–6	10	29	15	3	2	2	4	24%	Number of broods 2.8
March 2–4	16	33	27	6	5	3	10	42.4%	
April 5–7	16	32	22	5	6	3	10	43.7%	
May 2–4	21	32	34	3	2	0	10	15.6%	
June 1–3	20	23	20	2	1	0	6	13%	
Oct. 21–23	8	28	14	1	4	1	11	21.4%	*Thomomys perpallidus albatus*, El Centro, Calif.
Nov. 19–21	13	31	18	2	3	1	7	19.3%	
Dec. 10–12	6	41	15	3	4	2	18	21.9%	Males taken 100
Jan. 15–16	10	28	13	5	1	2	4	28.5%	Females taken 296
Feb. 10–12	7	23	23	1	1	1	3	13%	Average litter 3.91
March 10–12	8	46	20	8	5	2	15	32.6%	Number of broods 2.35
April 12–14	15	37	13	3	3	2	13	21.6%	
May 9–12	18	31	32	3	6	1	10	32.2%	
June 6–8	15	31	18	5	8	1	6	45%	

pallidus of the Imperial Valley has a ratio of replacement-and-increase in the species of 9.2 to 5, and *bottae* of the San Gabriel Valley, a ratio of 16.4 to 5; about double the rate of reproduction in one case and three times the rate in the other (see tables). The rate of replacement-and-increase for the calendar year of 4 seasons is still more favorable to the southern species than is indicated by the figures just given, for investigations of *perpallidus* and *bottae* cover but 9 months of the year. And, while their records represent approximate performance in the field, month by month, figures for the northern species are based on average litter only, without taking into account

the variable factor of unmated females considered in the southern groups. It will be understood that actual performance in the field, as indicated for the southern species, includes the compounding factor (not accurately determined) of litters produced within the twelve-month period by females themselves born within the calendar year. This compounding factor is absent in all of the northern groups investigated.

More complete data on the 5 species of pocket gopher herein considered are given in tables I and II.

By way of indicating the procedure followed in arriving at certain conclusions in this discussion, it may be said that an average litter factor was determined mainly by actual count of embryos in pregnant females, but supported also by the numbers of fetal scars in cases where birth of young had occurred within a few days to a week or more. In a few cases litters of young were found in nests, on excavation. Possible resorption of one or more of the fetuses between early pregnancy and birth was not taken into account, although this occurs not uncommonly.

The number-of-broods factor is determined by computing the total percentages of field pregnancy for the year, these percentages being obtained from records of field trappings at intervals of approximately the gestation period of the species.

Ratio of replacement-and-increase in the species is the product of number-of-broods factor by average-litter factor.

U. S. Biological Survey, Puyallup, Washington.

NOTES ON THE KILLING TECHNIQUE OF THE NEW YORK WEASEL

By Durward L. Allen

The ruthless savagery of the weasel in killing animals many times larger than itself has been featured in numerous accounts of its habits. Wherever the feeding of this animal is mentioned there is usually some reference to "blood sucking." Observers have referred to this habit (Audubon and Bachman 1849, Kennicott 1857, Anthony 1928), and many of the records were doubtless based upon personal observation; but the literature contains few specific descriptions of the technique of killing, and evidence is inconclusive that "blood sucking" is the usual feeding method of the weasel.

One of the most detailed descriptions of killing under natural conditions is given by Nelson (1918). While hunting on the Mexican tableland he saw a large pocket gopher and a weasel locked in a death struggle, rolling about on the ground. He shot the gopher and upon skinning it found that the teeth of the weasel had torn loose the muscles attached to the base of its skull nearly down to the cervical vertebrae. The injury had been inflicted without breaking the skin of the gopher.

Leopold (1937) described an excellent observation from Wisconsin. He saw a weasel pursue a one-third-grown rabbit, which it overtook and bit at the base of the skull. The rabbit collapsed and began kicking. The weasel then returned, struck again, and killed it. The animal was observed for several minutes while it licked blood from the wound. It then dragged the rabbit farther into cover and continued the licking.

Lantz (1914) mentioned the method of attack on fowls: "It is characteristic of the weasel to kill many victims when they are within reach. It makes a small but deep incision in the neck or under the wing of a fowl and takes the blood as long as it flows freely."

Miller (1931) fed a captive weasel (*Mustela f. longicauda*) brown rats and chipmunks in a large room. The weasel would throw its body into a coil over the rodent and hold it while biting the back of the head or neck. This author remarked that the toes are weakly clawed and poorly equipped for holding small and elusive prey.

In the early part of 1937, while making some field investigations in Kalamazoo County, Michigan, I captured in box traps, at different times, 4 male New York weasels (*Mustela frenata noveboracensis*). As cottontail rabbits were also being taken regularly in the traps, an opportunity was provided for studying, under artificial conditions, the manner in which these weasels would kill and feed upon adult rabbits.

The method used was to place the live weasel in a cage of quarter-inch mesh hardware cloth approximately 3 feet long, 2 feet wide, and 2 feet high. The bottom of the box was covered with several inches of straw and a small

bird house was placed in one corner in which the weasel could make a nest. At the time of each experiment an adult, live, male rabbit was placed in the cage and the weasel turned out of the bird house. The results of each experiment are described as they occurred.

A weasel taken on January 6 (a male as judged by its size) was left in the pen without food until January 8. On that date a rabbit (*Sylvilagus floridanus mearnsii*) weighing 2 pounds 9 ounces was placed in the pen. The weasel would not come out of its nest until turned out. It immediately noticed the rabbit, which was crouched in one corner. It approached and struck the rodent several times on the hip, uttering a sharp cry. It then struck the rabbit on the nose, which caused the animal to jump to the other end of the pen. As it alighted the weasel struck it at the base of the skull and the rabbit leaped again. This continued and at each leap the weasel would lose its hold but would strike again in an instant. It confined its further assaults principally to a point on top of the neck at the base of the skull. In a few moments the rabbit became quiet, whereupon its assailant continued to tear at the neck without interruption. It was spread out over the rabbit's back endeavoring to hold on with all four feet. But the animal would leap, dislodging the weasel, which would immediately return to the attack. After a brief time the leaping spells of the rabbit became shorter and its rests longer and more frequent. No cut was visible in the skin and there was little blood in evidence. After 8 minutes it was weakening rapidly and its head appeared very unsteady. The weasel shifted its attention to a point on the side of the neck behind the ear. Its jaws were used, not for biting, but with a raking motion. As the movements of the rabbit subsided the weasel would slide around its neck and try to fasten onto its throat; but in this position a spasmodic kick from the rabbit's powerful hind feet would cause it quickly to desist and to renew the attack on the back of the neck. After 10 minutes the rabbit was incapable of further resistance. The weasel quickly sought its throat and closed its jaws on the trachea. There was no longer any motion to the weasel's jaws, and it was apparent that the breathing of the rabbit was completely cut off. It gasped a few times and expired.

The weasel then began to run about the pen and to burrow through the straw. In 5 minutes more it had dragged the rabbit under the straw and completely covered it. In order to watch the action I uncovered the rabbit, but the weasel persisted and dragged it by the head under the straw again. An hour later I returned and removed the rabbit. An autopsy showed a single half-inch incision on the right side below the ear. Clotted blood had evidently been eaten from beneath the skin. The skin was removed from the back of the neck and it revealed that the canine teeth of the weasel had completely severed the dorsal neck muscles down to the cervical vertebrae. And yet the skin remained intact except for the aforementioned incision at

the side, which was made after the rabbit was dead. The teeth of the weasel had pierced the skin like needles and torn away the muscles without leaving any opening in the hide other than many tiny perforations that could be seen only from the under side.

The rabbit carcass was left in the weasel's pen for a week. The weasel began at the back of the neck and worked down onto the side, eating some flesh, bone, and skin each day. It finally ate all of the ribs from one side, and the viscera, seeming to prefer these parts to the back and hind quarters, which were untouched. Some of the fur was used for lining its nest in the bird house. The weasel escaped one night through a hole that had been overlooked.

The second weasel was kept in the pen 2 days without food. On the third day a live rabbit was liberated in the pen. The weasel rushed from its box and seized the rabbit by the nose but was jerked loose. It then attacked the inside of the rabbit's front leg and was struck several times by the hind feet and thrown against the side of the pen. Its attack immediately became less vicious and in a few moments it entered its house and did not come out again. Several hours later it was dead. An autopsy revealed blood clots in the pelvic region.

This animal appeared to have very little idea of a proper method of attack. It evidently considered the rabbit as proper prey but went about subduing it in a very crude manner. The rabbit, using its hind feet, delivered several truly terrific blows upon the person of its lighter adversary that were apparently the cause of the weasel's injury and death. These observations are somewhat at variance with the usual conception of the deadly efficiency of the weasel in killing its victims.

The third weasel was handled in the same manner as the other two. When the rabbit was placed in the cage, the weasel showed no interest at first. The nest box had to be removed from the cage in order to keep it from hiding. The rabbit, in like manner, disregarded the weasel and nibbled straw or sat up and "washed its face," with its enemy only a foot away. Both animals moved about for an hour before the weasel became sufficiently aroused to strike at the rabbit. For 15 minutes it dodged about the rodent, uttering its characteristic cry and nipping it on the flank, the shoulder, or the hind leg. Then it struck the rabbit below the eye and several times in the frontal region. The attack soon shifted to the base of the skull, and from there on the technique was essentially the same as in the first case. The struggle lasted much longer, however, and it was fully 15 minutes before the rabbit was subdued. The weasel then began to work down onto the right side of the neck. Its sharp teeth could be heard raking the back of the skull and it soon opened a long cut in the skin from the base of the ear down the side of the neck. Considerable blood was in evidence, which the weasel began to lick avidly. Intermittently it would cut deeper into the

side of the rabbit's neck to keep the wound open while it licked blood as a cat laps milk. After about 5 minutes the stomach region of the weasel assumed a perceptible bulge. The nest box had been returned to the cage and it entered this. By lifting the lid I ascertained that it had curled up and apparently gone to sleep. The rabbit was removed and examined. The muscles had been severed from the base of the skull as in the first case.

The fourth weasel was given a live chipmunk two days after being caught. It struck the chipmunk at the back of the head and arched its body around the animal, holding it with all four feet. In 30 seconds the chipmunk was dead. It appeared that the weasel had bitten through the skull, although the chipmunk was not retrieved for examination.

After several days the chipmunk had been almost completely consumed and a rabbit was tried. For an hour it was made to hop about in the pen, while the weasel took great care to keep out of its way. The weasel rushed about and hid under the straw, emitting high-pitched shrieks. It finally hid in the straw and would not come out; so the rabbit was removed. Two days later another rabbit was tried and, for the first hour, with similar results. The weasel seemed to be afraid of the rabbit and the rabbit appeared to take no notice. It licked its paws and groomed its head and appeared not in the least disturbed. Finally the weasel bit the rabbit on the hip. It then seized the rodent by the shoulder and was thrashed violently against the wire. The weasel tried again and was met by the hind feet. It began running very unsteadily around the pen and then entered the nest box. That night it was found dead. The injuries of this weasel were not determined.

Experiments carried out under such artificial conditions must not be too liberally interpreted; and yet they do, perhaps, furnish a few implications of value. A witness to the events described could not be other than impressed with the inefficiency of the weasel in handling an adult rabbit as prey. The hind feet of the rabbit are far too effective to permit a ventral attack. And the teeth of the weasel are too short and the head too small to enable it to inflict an immediately serious wound dorsally. The claws also, as remarked by Miller, are of little use for grasping. It appeared that weasels number 1 and 3 could make little progress in killing a rabbit until the animal was greatly weakened from shock. From these experiments it appeared that a rabbit in the open would have everything in its favor in a struggle with a weasel. The observation of Leopold, however, is readily understandable to those who have handled young rabbits and know how delicate and susceptible to shock these creatures are. The difference between handling even a half-grown animal and an adult is very great. It is probable also that an adult rabbit caught in a burrow would be a much easier victim than an animal with space in which to thrash about.

It is indubitable that rabbits form a considerable portion of the food of weasels in this region. Dearborn (1932) gave a frequency index of 14.29

per cent for *Sylvilagus* in the mammalian remains forming 83.34 per cent of 37 food specimens from southern Michigan. The statements of various authors indicate that rabbits are habitually taken. Audubon and Bachman (1849) stated that they have known a weasel to track a rabbit into a burrow and to kill it there. Kennicott (1857) also called attention to this habit. Stone and Cram (1920) averred that "In winter the larger weasels kill large numbers of gray rabbits." Seton (1929) referred to hares as a winter staple in the weasel's diet.

If the action of the 4 weasels used in these experiments be taken as an index, most adult rabbits in the wild must be killed at close quarters, probably for the most part in burrows. This is supported by the fact that most of the hunting of weasels is done in the burrows of its accustomed prey—mice and other small mammals. For this work its short legs and slim, sinuous body render it extremely efficient. Although individuals may develop rabbit-killing habits and necessity may alter conditions, it appears probable that adult rabbits are near the upper size limit of the mammalian prey that the New York weasel is capable of utilizing.

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Allegan, Michigan.

AGE OF SEXUAL MATURITY IN MICE OF THE GENUS PEROMYSCUS

By Frank H. Clark

The success of any species of small mammal under natural conditions is in part dependent upon its reproductive rate, and this in turn depends partially upon the age at which the young attain sexual maturity. Early sexual maturity in a polyestrous mammal may make possible the production of two or more generations of descendants in one year. Although laboratory studies cannot determine the actual reproductive rate of small mammals under natural conditions, there is doubtless a strong correlation between the age of sexual maturity in the laboratory and in the natural habitat.

In the present study, the age at which mice of the genus *Peromyscus* attain sexual maturity was determined by means of vaginal smears and of matings for the females, and by an examination of the epididymal contents for sperm, supplemented by matings, for the males. Since the mice of this genus appear to be polygamous, under natural conditions matings probably occur frequently between young females and old males. If such be the case, the determination of the age of attainment of sexual maturity is much more important for the females than for the males.

Materials and methods.—This investigation, conducted at the Laboratory of Vertebrate Genetics, University of Michigan, made use of all of the species of *Peromyscus* available at the time. Females of 6 species of *Peromyscus* were studied, namely *P. eremicus, maniculatus, polionotus, leucopus, truei,* and *boylii*. Each species was represented by females of from 1 to 5 subspecies. The species *eremicus* was represented by the subspecies *eremicus* and *fraterculus*; the species *maniculatus* by the subspecies *osgoodi, nebrascensis,* and by mutant stocks resulting from a mixture of several subspecies; the species *polionotus* by the subspecies *polionotus, albifrons, leucocephalus,* and *rhoadsi*; the species *leucopus* by the single subspecies *noveboracensis*; the species *truei* by the subspecies *truei;* and the species *boylii* by the subspecies *rowleyi*. At the completion of this study, it was found that the results from the various subspecies or stocks of any one species do not differ appreciably from one another, so they are combined and only the averages for each species are listed in the table.

Thirty-two to 186 females of each species were examined 4 times weekly beginning at the age of 22 to 25 days in order to determine the age when the vagina opens. When the vagina was observed to be open, smears of the vaginal contents were made. Females were regarded as sexually mature when the vagina had opened and the vaginal cell content consisted predominantly of cornified epithelial cells. In practically every female, the time of the opening of the vagina coincided with the time of the occurrence of the first cornified vaginal smear. It was demonstrated in a previous

study (Clark, 1936) in the deer-mouse, *Peromyscus maniculatus*, that ovulation occurs spontaneously during the cornified cell stage (estrum) of the estrous cycle, a stage that lasts for approximately 26 hours and is repeated about every fifth day in fertile unmated deer-mice.

With the exception of the females of the mutant *maniculatus* stock, all of the females of each species used were the immediate descendants of wild-caught parents and were, presumably, a genetically heterogeneous group. For this reason, females of the same species might be expected to differ somewhat in regard to the age at which sexual maturity is reached.

The approximate age at which male mice of the genus *Peromyscus* attain sexual maturity was determined by killing the animals and examining the epididymal contents microscopically for motile sperm. Some of the males were sacrificed at the age of 40 days and others at the age of 60 days. No males of the wild stocks could be spared for this study and, therefore, mostly young surplus males of the mutant *maniculatus* stock were used.

Further data on the age of sexual maturity was obtained from matings. Several females of each of the 6 species used in the present study were mated with males of the same species when a cornified vaginal smear indicated that the former were in estrum. When possible, they were mated with older males of proven fertility. By subtracting the minimum length of gestation period (22 days, Svihla, 1932) from the age in days of the female at birth of the first litter, the approximate age of the female when conception took place could be determined. The age at which young male and female mice first mated with resulting conception was also calculated in similar manner from routine laboratory records of the mutant stocks of *maniculatus*. Mice of the other stocks were usually mated when too old for such determinations.

Age of sexual maturity of females.—The average age at which female mice of each of the 6 species reach sexual maturity, as indicated by vaginal smears, is shown in table 1. If opening of the vagina and first estrum is a reliable index of attainment of sexual maturity, females of the species *polionotus* mature at a significantly earlier age (29.64 ± 0.47 days) than females of any of the other species. Some *polionotus* females exhibited a cornified smear when 23 days old and variation in age at first estrum was much less than in the other species. *Eremicus* females attain sexual maturity about 10 days later than females of *polionotus*, but mature significantly earlier than females of the species *maniculatus*, *truei* and *boylii*. Maturity is also earlier in *eremicus* than in *leucopus*, but the difference is of doubtful significance. The difference in age at sexual maturity between *polionotus* and *eremicus* is highly significant. Females of the species *leucopus*, *maniculatus*, *truei* and *boylii*, on the average, reach sexual maturity at between 46 and 51 days of age, and do not differ significantly from each other. The early maturity of *polionotus* is not surprising in view of its small body size. Mice of the

species *eremicus, maniculatus,* and *leucopus* are nearly twice as large as mice of the species *polionotus,* and are quite similar to each other in body size. It should be emphasized, however, that both larger and smaller subspecies of *maniculatus* than those used in this experiment do occur. *P. boylii* and particularly *P. truei* are larger than the other species in body size and tend to mature slightly later.

Age of sexual maturity of males.—As already stated, males of the wild stocks could not be spared for this study. A miscellaneous group consisting mostly of mutant males that were hybrids between several races of *maniculatus* were used. Seventy-nine of these males were examined when approximately 40 days of age. Thirteen of them had many motile sperm, 16 had a few motile sperm, and 50 had no motile sperm in the epididymis. There were then only 16.5 per cent of this group with abundant motile sperm that could be regarded as sexually mature. Forty-three males of the species *maniculatus* were killed and examined at 60 days of age. Thirty-four of

TABLE 1

AGE IN DAYS AT WHICH FEMALES OF DIFFERENT SPECIES OF PEROMYSCUS ATTAIN SEXUAL MATURITY

SPECIES	NO. OF MICE	AVERAGE AGE AT FIRST ESTRUM	AGE AT EARLIEST ESTRUM
P. eremicus	61	39.21 ± 1.54	28
P. maniculatus	186	48.72 ± 1.23	28
P. polionotus	121	29.64 ± 0.47	23
P. leucopus	32	46.22 ± 3.18	28
P. truei	34	50.09 ± 2.44	28
P. boylii	33	50.93 ± 1.92	37

these males, or 79 per cent, had an abundance of motile sperm and may be regarded as sexually mature. Six others had a few sperm and only 3 exhibited no motile sperm. Eight males of the species *eremicus* were examined when 40 days old, and motile sperm were found in the epididymis of only one of these 8 males. These results indicate that males of the species *maniculatus* at least, tend to mature a little later than females. Many of the *maniculatus* females are mature at 40 days of age but only a few males are sexually mature at that age. In this species there is apparently about 10 days difference in age of sexual maturity between males and females.

Results of matings.—Females of the several species that were tested for sexual maturity by means of vaginal smears were mated with males of the same species as soon as a cornified cell smear indicated that the former were sexually mature. A considerable number of matings were made in each species during the winter, spring, and early summer months. Matings were allowed to run for at least three months, but all matings were broken in Octo-

ber because mice of the genus *Peromyscus* reproduce very little during the fall and early winter months. The peak of reproductive activity occurs from February to June, and then, after a brief lessening of breeding activity, litters often appear from mated pairs in August and September. A few females apparently breed throughout the year. The results of these matings were very disappointing, due, perhaps, to the fact that fully one-half of the matings were made in late spring or early summer.

Twenty-five matings were made between mice of the species *maniculatus* and 6 of these were successful. One female conceived when approximately 50 days of age and 4 of the 6 females conceived when 50 to 60 days old. Twenty-nine pairs of mice of the species *eremicus* were mated and 8 females produced young. One of these females was only 58 days of age when conception took place, while the others were older. Only one out of 12 mated pairs of *polionotus* produced young and the female of this pair was about 102 days old when conception took place. It seems reasonable to suppose that most of the females of this species would be capable of fertile matings when much younger. Twelve other females of this same species were each mated with a male for 24 hours during their first estrum. None of these females produced young. If ova are spontaneously liberated at the first estrum, it is surprising that some of these females did not conceive. These mice are far from mature in body size, however, when the first estrum occurs. Seventeen pairs of *leucopus* were mated and 5 matings were successful. One female was only about 39 days of age when conception took place while another was about 61 days old. Twenty-four pairs of *truei* were mated late in the season and 3 of these produced young. All three females were more than 3 months of age when conception took place. Nineteen pairs of *boylii* were mated and only 2 matings were successful. In both cases the females were more than 4 months old when fertilization occurred.

Some data on age at first conception was obtained from the mating cards of the mutant *maniculatus* stocks, although most of the matings of these mice were made when they were too old to be of use in determining age of sexual maturity. The records were used only in cases where one or both members of a given pair were mated when immature. When both animals of a pair were young a fertile mating could not take place, of course, until both animals were sexually mature. These data indicate that one male was fertile at 40 days of age, 6 were fertile when 50 to 54 days old, 3 were fertile at 50 to 59 days of age, and 3 were fertile when between 60 to 70 days old. Considering the females, we find that two of them were approximately 34 days old when conception took place, while 8 others were between 45 and 70 days of age.

Discussion.—Without doubt, the actual production of young by any animal is the best proof of the attainment of sexual maturity. The chief objection to using matings as an indication of sexual maturity is that there are two

variables instead of one. If no young are produced from a mating, the female may be fertile and the male sterile (or immature), or the reverse, or both animals may be at fault. Then, too, as previously pointed out, success of a mating may be influenced by the time of year when the mating is made. In any event, the fact that one *leucopus* female conceived when 39 days old and two mutant *maniculatus* females both conceived at 34 days of age indicates that the young females tested by the vaginal smear method were really sexually mature at the time the smear first consisted of cornified cells, and that the first ovulation takes place at that time or soon after. The occurrence of the first cornified cell stage (estrum) is an indication of approaching sexual maturity and is undeniably a valuable index for comparing the sexual development of related species of mice.

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A RECONSIDERATION OF THE SHOULDER MUSCULATURE OF THE CAPE GOLDEN MOLE

By Berry Campbell

The investigation herewith reported on the anatomy of *Chrysochloris* is a sequel to a study that I previously made on the shoulder structure of the principal genera of the moles, Talpidae. It is my purpose here to offer a corresponding analysis of the Chrysochloridae, based upon a dissection of a specimen (no. B 1836) of *Chrysochloris* sp. from the Hamann Museum. Dobson (1882–1892), in his monograph on the Insectivora, described the osteology and the myology of this genus. Later, Parsons (1901) reported on another dissection of the muscles and joints. Aside from these two papers, no important contribution to our knowledge of the anatomy of the forearm of this animal has been made, and the paucity of literature prompts me to discuss in full the characteristics of each of the bones and muscles, even in those instances where my dissections are in agreement with the literature; for corroboration in such a poorly known subject is a necessary part of the discussion. The main object of this paper is to throw some light on the question as to the similarity or dissimilarity of the ways in which the two families have become adapted to a subterranean life.

Based on work done at the Laboratory of Anatomy, Western Reserve University, while the author held a National Research Council Fellowship in the Medical Sciences.

OSTEOLOGY

Thorax.—X-ray photographs of the intact animal do not fully substantiate Dobson's statement (p. 108) that the advantages in reducing the diameter of the body, in the shoulder region of the Talpidae, through elongation of the manubrium sterni and shortening of the clavicles in order to accommodate the pectoral girdle in the neck region, has been compensated for in *Chrysochloris* by the hollowing out of the anterior thoracic walls. The anterior migration of the fore limb has gone quite as far as in the true moles, for in each the shoulder joint lies at the level of the first or second cervical vertebra. But the difference of the arrangements of the parts has caused the elbow of the Cape golden mole to lie opposite the first two ribs instead of being turned away from the body. It will be seen, however, that even though the sternum is bowed inward, there is no apparent hollowing of the anterolateral walls of the thorax. It should also be remarked that the manubrium, although not as elongate as that of *Condylura* (the shape of which it strongly resembles) is definitely lengthened.

Manubrium sterni.—There is a strong similarity between this bone and that of the true moles. The three tendencies that characterize it in the talpids—lengthening, development of a keel, and formation of lateral wings—have operated in this instance to produce a structure very similar to that of *Condylura*. There is one important difference, however, namely, the absence of clavicular facets, for in *Chrysochloris* the clavicle (Parsons), instead of articulating with the sternum, is bound to the anterior tip by a fibrous strand of tissue 5 mm. long.

Clavicle.—The clavicle is long and exhibits a sigmoid curve. As mentioned above, the sternal end has degenerated to form a fibrous connection. Laterally the bone articulates with the acromion. The small diameter, as well as the absence of a fixed medial joint, would indicate that tension is the only mechanical stress placed upon the clavicle.

Scapula.—The scapula shows, to a slight extent, a tendency toward narrowing, as is so frequently found in fossorial animals. The three major fossae are well indicated. Although thickened, the axillary margin presents no unusual features, save for a great reduction in the teres major fossa. That area is strictly limited to the inferior angle. The spine is low and the tuber scarcely indicated. The acromion, large and heavy, bears a fingerlike metacromion. The glenoid cavity is elliptical; rotation of the humerus is thus impossible.

Humerus.—The humerus is remarkable for the large size of the internal tuberosity, the poor development of the external tuberosity, the obvious bicipital groove running the entire length of the shaft, and most of all for the tremendous elongation of the entepicondyle. There is a deltopectoral eminence on the anterior surface of the lower third of the bone, for the insertion of most of the pectoralis superficialis as well as the acromiodeltoid. Underneath the medial edge of this prominence, the belly of the biceps forms an obtuse angle as over a pulley surface. The lateral epicondyle is moderately developed for the origin of the forearm extensors. There is a well marked olecranon fossa.

MYOLOGY

Trapezius.—As reported by Dobson and by Parsons, I found the trapezius to consist of a thin anterior portion with a long straplike posterior part. The first is divided dorsally so that the anterior part of the muscle arises from the medial three-fourths of the occipital margin, while the rest arises from the midline of the neck. Its insertion is on the tip of the metacromion. The posterior part of the trapezius arises from the midthoracic region and inserts into the tuber.

Sternocleidomastoideus.—Three elements are present—the sternomastoid, cleidomastoid, and cleido-occipitalis. In Dobson's specimen the first two were fused; in mine, the second two, while in Parsons' specimen, all three were distinct. The insertion of the clavicular divisions is on the bony clavicle and not on the fibrous part.

Serratus anterior.—This is divided into cervical and thoracic sections. The former has a rather constricted origin from the last 4 or 5 cervical transverse processes. From there it fans out to a remarkable insertion that extends from the clavicular articulation on the acromion along the anterior edge of the acromion and spine as far as the tuber, at which point it extends across the fascia of the supraspinatus and finally meets the insertion of the thoracic section at the superior angle. Such a widespread insertion may well represent the original attachment of the muscle, but it is rarely encountered in Recent mammals. The thoracic serratus, as usual, originates by digitations from ribs 1-10 (1-8, Dobson) and inserts on the vertebral margin of the scapula.

Atlantoscapularis anterior.—This muscle presents a curious doubling which seems to be constant in all of the dissections. It arises on the wing of the atlas and runs lateralward as two stout muscles. The smaller of these inserts on the lateral surface of the tip of the metacromion; the other, which is several times as large, inserts on the dorsal surface of the acromion. Neither justifies Dobson's name of levator claviculae, although it is possible that the larger of the two has migrated from the clavicle onto the acromion.

Rhomboideus capitis.—As in Dobson's specimen, this stout muscle arises from the lateral two-thirds of the occipital crest, and inserts on the vertebral half of the acromion and along the reduced spine obliquely to the superior angle.

Rhomboideus cervicis.—Not entirely separate from the capitis portion, this very heavy muscle takes origin not only from the entire dorsal midline of the neck but from the medial third of the occipital crest as well. Insertion is on the reduced spine of the scapula and on a triangular area at the base of the spine. It is not entirely separable on its deep surface from the capitis.

Rhomboideus thoracis.—This comprises a true interscapularis muscle, as in the Talpidae. Origin is from a tendinous inscription, continuous anteriorly with the nuchal ligament, that represents the fused origins of the two antimeres. Insertion is on the edge of the inferior angle of the scapula. There is a curious parallelism between the muscle as found in this animal and in the desman, *Galemys*. In both species the serratus posterior superior inserts, from below, on the tendinous inscription between the posterior rhomboidei and a peculiar X-shaped structure is formed, the two lower limbs of which are formed by the serrati, and the upper limbs by the rhomboids. Neither Dobson nor Parsons described this condition in *Chrysochloris*.

Latissimus dorsi.—One of the most remarkable muscular mechanisms found in this animal is the peculiar double latissimus. The larger part, and the more superficial, arises from Th. 9 to rib 5. It appears as an ordinary latissimus. Insertion is on the elongated medial condyle and also to a slight extent on the fascia of the forearm flexors. The deeper and aberrant slip is about one-third the bulk of the former. Arising from the twelfth to the seventeenth ribs it lies partly under the ventral edge of the other and inserts by means of a short aponeurosis on the superficial surface of the costal portion of the pectoralis superficialis. Although Dobson described this as a part of the pectoralis musculature, the innervation comes through twigs of the thoracodorsal nerve. Parsons omitted this curious muscle from his figure and text.

The fact that this accessory slip of the latissimus inserts on that part of the pectoral musculature that attaches to the lesser tuberosity raises a very interesting question of muscle phylogeny. Thus it may represent a section of the muscle whose insertion did not migrate down to the entepicondyle or it may have subsequently been derived from elements that did.

Teres major.—This usually robust and useful muscle has reached a curious state of atrophy in the Cape golden mole. Origin is from the inferior angle of the scapula, and insertion is on the medial edge of the humerus directly across the bicipital groove from the deltopectoral tuberosity. The insertion is not marked on the skeleton in this collec-

tion. Dobson, who never was very clear on the scapular muscles, designated this structure as the teres minor, but its true homology was determined by Parsons.

Subscapularis.—This is a very heavy muscle—a fact correlated with the great development of the lesser tuberosity. It arises from the entire fossa and has a fleshy insertion on the lesser tuberosity. My specimen lacked the subscapularis accessorius described by Parsons.

Spinodeltoideus.—In many mammals it is impossible to make a distinction between the spinodeltoid and the teres minor, although in *Homo* the separation is clear. In the species here discussed the differentiation of the axillary field either has not resulted in the separation of these two muscles or else one of them has been lost. The large spino-

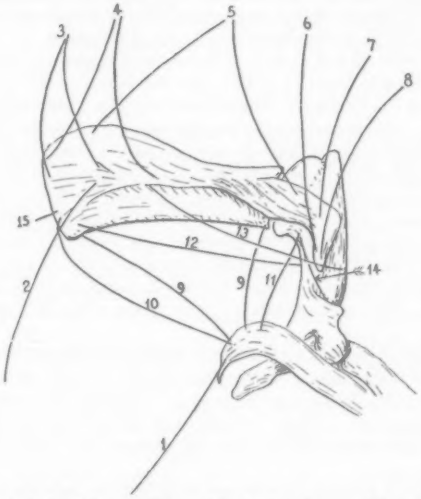

FIG. 1. Articulated shoulder of *Chrysochloris* showing position of muscles. 1. Latissimus dorsi. 2. Posterior part of trapezius. 3. Rhomboideus capitis. 4. Rhomboideus cervicis. 5. Serratus anterior cervicis. 6. Anterior part of trapezius. 7. Larger part of the atlantoscapularis anterior. 8. Smaller part of atlantoscapularis anterior. 9. Scapular triceps. 10. Extra origin of scapular triceps. 11. Triceps lateralis. 12. Teres major. 13. Spino-deltoid. 14. Brachialis anterior. 15. Interscapularis (rhomboideus thoracis).

deltoid seems to be comparable in all respects to that of the true moles (even in being wrongly labelled the infraspinatus by Dobson). It arises from the dorsal lip of the posterior border of the scapula and on the spine, from its root to the level of the glenoid. It thus encloses dorsally and posteriorly the infraspinatus, to the fascia of which it is attached. The unmarked insertion is on the lateral edge of the humerus between the greater tuberosity and the proximal root of the deltopectoral eminence. The relations between this muscle and the scapular head of the triceps are curious. The latter muscle, as illustrated by Dobson, arises deep to the spinodeltoid along all of the posterior border of the scapula, and is reflected back superficially along the vertebral two-fifths of that border.

Cleidodeltoideus (*acromiodeltoideus*).—This part of the deltoid complex is represented by two muscles. One of these is a very narrow band arising from the medial third of the clavicle and inserting on the proximal root of the deltopectoral prominence. This would seem to be a part of the pectoralis superficialis group (as indeed Dobson so considered it) but its axillary innervation reveals its true nature. Both clavicular and acromial elements enter into the middle deltoid. It arises from the lateral two-fifths of the clavicle and from the distal or caudal edge of the acromion. It passes deep to the narrow band described above, and inserts more distally on the deltopectoral tuberosity.

Supraspinatus.—This is a well developed muscle with origin from the entire supraspinous fossa and insertion on the proximal surface of the greater tuberosity.

Infraspinatus.—This muscle, entirely hidden by the spinodeltoid, arises from the infraspinous fossa and inserts on the greater tuberosity lateral to the insertion of the supraspinatus. Its suprascapular innervation was determined.

Pectoralis superficialis (*et profundus*).—This muscle shows no unusual development anteriorly. The clavicular head is absent (see cleidodeltoid above) and there is no precapsular head as in the Talpidae. There is a very poor differentiation into capsular and sternal portions. Origin is from the manubrium, the entire length of the sternum, from the expanded portion of the first rib, and from the ventral thirds of the true ribs. The portion arising from the ribs is very unequally developed in my specimen: on the right side it is heavy and extends farther dorsally than on the left. The insertion of the sternal part of the muscle, which forms the greatest bulk, is on the deltopectoral tuberosity, while the parts arising from the ribs insert on the lesser tuberosity and on a stout fascial arch running from that structure, superficial to the belly of the biceps, to the lesser tuberosity. Thus the costal origin in all likelihood represents the pectoralis profundus but, being continuous with the superficial pectoral at the origin and insertion, its delimitation is impossible.

There is some discrepancy in Dobson's description and figures regarding the dorsal extent of the origin of this muscle. Apparently what he termed the dorsal part is actually the posterior slip of the latissimus (see above). Parsons did not discuss the pectoral muscles, but as he described a simple latissimus in his specimen, the posterior slip, if present, must have been considered by him as pectoral in origin. His figure is noncommittal.

Panniculus carnosus.—I made no attempt to follow any but the thoracic portion of this muscle. This is strongly developed and consists of two sets of fibers. One (acromiocuticularis, Dobson) of these radiates away from its attachment on the tip of the metacromion to the midline of the neck and extends posteriorly and ventrally over the entire back and side region, and onto the belly posterior to the middle of the sternum. From the midline of the manubrium arises another set of fibers (sternocuticularis, Dobson) that fans out to interlace with the other system over the lateral thorax.

Subclavius.—This consists of two muscles, fused at insertion. The first arises by a flat tendon from the lateral edge of the manubrium, the other by tendon from the anterior edge of the flattened end of the first rib. Insertion is on the distal third of the clavicle (mainly costal fibers), on the greater tuberosity, the glenoid border of the scapula, and on the fascia of the supraspinatus. This agrees essentially with the conditions reported by Dobson. Parsons, however, mentioned no manubrial origin.

Coracobrachialis.—Absent.

Biceps brachii.—One head only of this muscle is present. Origin is by a short tendon from a tubercle on the anterior edge of the glenoid. The muscle has a long fleshy belly that lies in the bicipital groove and curves under the deltopectoral process. Insertion is on the radius and ulna by means of a short tendon.

Brachialis anterior.—This muscle, considered absent by Dobson, was well described

by Parsons. Origin is distal to that of the humeral triceps from the anatomical neck (hardly the surgical neck as reported by Parsons), with insertion fused to that of the biceps on both radius and ulna.

Triceps.—The extremely heavy scapular triceps, which takes origin along the entire axillary margin of the scapula, has wandered onto the vertebral end of the infraspinous fossa. This aberrant origin was considered by Dobson to be the teres major, but Parsons pointed out its relationship to the triceps and mentioned this as a not uncommon condition in fossorial mammals. The two humeral heads are small in relation to the scapular part. The origins of the lateral and medial heads are continuous and extend along the distal edge of the anatomical neck of the humerus to a fossa between the head and the lesser tuberosity of the bone. Insertion of the entire triceps is on the long curved olecranon process; the scapular portion attaches laterally.

Anconeus.—A small anconeus takes origin from the olecranal fossa and inserts the basal portion of the olecranon.

DISCUSSION

A comparison of the shoulder anatomy of *Chrysochloris* with that of the true moles shows that the locomotion of the two groups is fundamentally different. In the talpid type of shoulder the humerus acts in a horizontal plane; retraction of the manus is accomplished primarily by humeral rotation through the action of the teres major, subscapularis, and latissimus dorsi; and the clavicle is constructed and placed so as to transmit, as compression upon the axial skeleton, all of the counterthrust of digging (or the equal and opposite reaction of the soil against the hand). This method of digging is considered to be unique among mammals. The locomotor specialization of *Chrysochloris* is merely a variation of an old theme, for basically the shoulder pattern of this form is similar to that of nearly all other digging or running mammals and there is no evidence implying divergence from the "terrier method" of digging, in which the animal, bracing itself with the hind legs, digs by means of running motions of the anterior limbs.

The structure of the burrowing mechanism in *Chrysochloris* is so like that of cursorial progression that no new morphological problem appears in the shoulder region. Certain minor peculiarities, however, distinguish *Chrysochloris* from the other burrowers of this type. Chief among these are the weakness of the teres major and the distal migration of the insertion of the latissimus dorsi. These muscles, both retractors of the humerus, generally act through levers of the third class inserting near the fulcrum or head of the humerus and working on the elbow joint. In the Cape golden mole the former muscle is very weak and the latter has shifted its insertion distally so that it has transformed the lever system to one of the second class. This is a sacrifice of speed for power and is a clue to the general heaviness of muscular and bony development. Specimens of the rodents *Thomomys* and *Georhychus*, also in the Hamann Museum, which I have dissected, show that, while they also have extremely fossorial habits, their shoulders exhibit only weak muscles and slender bones. In fact, the manner of their digging is scarcely reflected in their anatomy, although it is probably fundamentally similar to that of *Chrysochloris*. It seems reasonable, however, that the Cape golden mole progresses by means of methodical thrusts of great strength (after the manner of true moles), while the rodents accomplish the same ends by means of rapid scratching. Thus the specializations responsible for the subterranean proclivities of *Chrysochloris* seem to be centered mainly on the shoulder; in the two rodents mentioned the digging abilities are due instead to behavior pattern alone. Records of direct observation upon these rare animals are imperative to test the validity of these theories, based solely on morphological findings.

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NOTES ON THE HARES OF BRITISH COLUMBIA WITH THE DESCRIPTION OF A NEW RACE

BY IAN MCT. COWAN

For several years it has been suspected that two very distinct races of varying hares inhabit the eastern and south central parts of British Columbia, a region currently recognized as occupied by but one race, *Lepus americanus columbiensis*. Material now in the British Columbia Provincial Museum, together with the interesting series of hares in the Kenneth Racey collection, confirm this suspicion and serve to clarify some of the puzzling features of the distribution of hares in western British Columbia.

The area including the Selkirk Range north at least to the "Big Bend" of the Columbia River, the Monashee (Gold) Range for an undetermined distance north, and probably also the western slope of the Rocky Mountains and the valleys between these ranges, is inhabited by one of these geographic races. Here the hares in summer pelage have a pale reddish-brown dorsal coloration, sharply contrasting clear reddish-brown head and face, grayish-white under-fur, and strongly colored ears, whitish inside darkening to grayish brown marginally, edged with white and tipped with black.

North of this area in the region roughly comprising the Caribou, Chilcotin, and southern Omineca districts of British Columbia, there is found a hare differing markedly from the Selkirk race. In this region the animals resemble *americanus* closely in size and color pattern but are somewhat paler, being dull colored, pale grayish-brown, the heads much the same color as the backs rather than contrasting, insides of ears dun colored and often without dark margin and white edge, underfur in summer dark gray.

In his original description of *L. a. columbiensis*, Rhoads described as the type a specimen from Vernon, British Columbia, and referred also to another specimen from between Ashcroft and Clinton. He described the race as distinguished from all the other races of *americanus* "by its general greyness and almost total absence of rufous above".

Vernon is unfortunately almost in the middle of an area in which three-way intergradation is taking place between the two above-mentioned populations and *cascadensis* from the coastal slope of British Columbia. The type

specimen is obviously an intergrade between the Selkirk race and the Chilcotin race. A series of 7 topotypes before me all show signs of intergradation. On the average, however, the Vernon specimens are plainly closest to the Selkirk population. I have not examined hares from near Ashcroft, but individuals from a few miles north of Clinton and in the same type of country are of the gray Caribou and Chilcotin race.

COMPARATIVE MEASUREMENTS OF FOUR RACES OF THE VARYING HARE

NUMBER OF SPECIMENS MEASURED	LOCALITY		TOTAL LENGTH	LENGTH OF HIND FOOT	LENGTH OF EAR FROM NOTCH	BASILAR LENGTH OF HENSEL	ZYGOMATIC BREADTH	LEAST INTERORBITAL BREADTH	ALVEOLAR LENGTH UPPER MOLAR SERIES	NASAL LENGTH	GREATEST WIDTH COMBINED NASALS	PALATAL WIDTH	GREATEST WIDTH INTERPTERYGOID FOSSA	ANTERO-POSTERIOR DIAMETER AUDITORY BULLA	WIDTH BRAIN CASE BETWEEN AUD. MEATI
								americanus							
4	Lake Abitibi, Ont.	Mean	442	133	65.7	61.1	39.3	11.0	15.2	32.6	17.0	12.0	7.4	10.1	24
		Min.	412	125	62.0	55.5	39.0	10.0	14.4	29.6	15.8	11.6	7.0	9.0	24
		Max.	465	144	70.0	63.8	39.5	12.4	15.5	35.0	18.3	12.6	8.0	10.8	24
								macfarlani							
5	Atlin, B. C.	Mean	*489	*147	*67	59.3	38.1	12.1	14.7	31.0	15.7	12.5	7.3	10.2	23.5
		Min.				57.0	36.6	11.0	14.0	29.4	15.0	11.4	6.6	9.6	22.0
		Max.				63.0	39.6	13.0	15.5	32.5	17.0	14.3	7.8	11.0	24.6
								pallidus							
7	Chezacut, B. C.	Mean	452	138	67	58.7	37.6	10.8	14.1	31.4	15.5	11.2	7.1	11.2	23.9
		Min.	437	130	63	56.0	36.1	9.0	13.5	28.7	14.5	10.7	6.7	10.8	23.3
		Max.	473	144	72	60.0	39.0	12.7	14.4	33.5	17.6	11.5	7.5	11.6	24.6
								columbiensis							
8	Selkirk and Gold Ranges, B. C.	Mean	441	145	73	58.6	38.7	11.4	13.6	30.3	16.2	11.7	8.4	10.7	23.9
		Min.	410	135	69	56.0	36.3	10.7	12.8	29.0	14.6	10.7	7.5	10.3	22.8
		Max.	470	156	77	62.6	41.6	12.4	14.4	31.7	18.5	13.0	9.5	11.5	24.8

* From Nelson, E. W., North Amer. Fauna no. 29.

It seems evident from Rhoads' description that the animal he was describing was the pale race of the Chilcotin and Caribou; however, inasmuch as he chose as his type an intergrade, which in light of present knowledge is plainly closer to the Selkirk race, and furthermore, as Nelson in the capacity of first reviser applied the name *columbiensis* to the rabbits of Vernon and eastward (i.e. the Selkirk race), it seems advisable to retain that application of the name. This action leaves the pale race of rabbits inhabiting the Chil-

cotin and Caribou districts without a name. I propose that it shall be known as follows:

Lepus americanus pallidus subsp. nov.

Type.—Female adult, skin and skull, no. 394, collection I. McT. Cowan; taken July 29, 1931, by I. McT. Cowan at Chezacut Lake, on the Chilcotin River, British Columbia. Orig. no. 660, collection of Kenneth Racey. The type has been deposited in the British Columbia Provincial Museum.

Range—British Columbia east of the Coast Range, south to the Thompson and South Thompson rivers, north at least to Ootsa Lake, east at least to Indianpoint Lake. Probably also inhabits the western slope of the northern Rocky Mountains in the vicinity of Robson, British Columbia, and northward.

Diagnosis.—A dull colored rabbit most like *americanus* but differing from it in longer hind feet and ears, and smaller skull with very much larger auditory bullae.

Measurements.—Average of 7 adults of both sexes from the type locality. Total length, 452 mm. (437–473); hind foot, 138 (130–144); ear of dry skin, 67 (63–72); tail vertebrae, measured after skinning, 38 (35–41).

Color.—Light color of upperparts nearest Pinkish Buff of Ridgway (Color Standards and Color Nomenclature, 1912) but often paler, at times almost white, dorsal surfaces with usual admixture of black, this becoming more pronounced on rump; underside of neck and sides of head between Cinnamon Buff and Light Pinkish Cinnamon. Crown much the same as dorsal surfaces; sides grayish, underparts white; outside of hind legs with band of Ochraceous Buff; hind feet above varying from white to Ochraceous Buff; below Drab; ears brownish inside, sometimes with narrow white margin; outside, color of back, tips Fuscous.

Comparisons.—On external appearance alone the new race differs markedly from all adjoining races except *americanus*. From *macfarlani*, *pallidus* differs in its smaller size, smaller hind feet and ears, paler and browner coloration, less black dorsally, and in having sides of face and under side of neck brownish rather than grayish. From *columbiensis* and *cascadensis*, *pallidus* differs in its predominantly yellowish-brown or grayish-brown, rather than reddish-brown dorsal coloration; the head dull rusty yellowish, only slightly differentiated in color from dorsal parts of body, rather than between Pinkish Cinnamon and Light Pinkish Cinnamon and contrasting strongly with rest of body; the dark rather than whitish underfur, and the drab almost monocolor inner surfaces of the ears likewise distinguish *pallidus* from these races.

The yellowest specimens of *pallidus* are indistinguishable from the grayest specimens of *americanus* as represented by 4 adults, but on the average *pallidus* is paler and grayer than *americanus* and generally with less black dorsally. *Pallidus* is distinguishable from this race also in having larger hind feet and longer ears.

Cranially the narrower skull, relatively narrower interorbitally, with shorter, lighter posterior supraorbital bars, markedly less depressed frontal region with correspondingly less prominent supraorbital ridges, longer tooth row, relatively narrower nasals, absence of strong laterally projecting wings midway on dorsal margin of jugals, narrower interpterygoid fossa and slightly larger bullae, readily distinguish *pallidus* from *columbiensis;* while the larger heavier skull with supraorbital well developed and usually lacking the anterior segment, serves to distinguish the new race from *cascadensis*. In comparison with *macfarlani*, *pallidus* has the interorbital region narrower, skull smaller, palate relatively narrower (79% rather than 85% of alveolar length of upper molar series), auditory bullae actually and therefore relatively larger; interorbital part of frontal region flat or depressed below level of extreme dorsal elevation of supraorbital processes, rather than strongly elevated. From *americanus*, the smaller skull with relatively

narrower nasals, palatal bridge with posteromedian spine always present rather than generally absent, and the very much larger auditory bullae of *pallidus*, serve as differentiating features.

Specimens examined.—All from British Columbia. *L. a. pallidus:* Chezacut Lake, 10; Indianpoint Lake, 5; Lac La Hache, 1; Wentworth Lake, 2; *Sicamous, 1; 83 mile on Caribou highway, 1; Quesnel, 1. *L. a. columbiensis.*—Monashee Pass, 3; Mount Revelstoke 10; Okanagan Falls, 1; *Okanagan Landing, 1; *Okanagan (virtual topotypes) 6. *Indicates specimens showing intergradation with the other race.

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GENERAL NOTES

A CONVENIENT METHOD OF MOUNTING AND STORING THE SKINS OF SMALL MAMMALS

The usual method of preparing "round" skins, tying labels on them, and storing them in drawers, has certain disadvantages, among which are the space that they occupy, the inconvenience of finding a particular specimen when it is wanted, and the chance of labels becoming detached from the specimen and of the tail and legs being broken off. Among the advantages assumed for this method are that the large number already so prepared and their similarity to the natural shape of the animal make comparisons easier in the museum and in the field. The other method, of preparing flat or "cased" skins, has under present practice many of the same drawbacks and neither of the advantages of the first. The present note suggests for consideration several ways by which cased skins can be mounted and stored in such manner as to obviate many of the drawbacks.

Since Dr. R. M. Anderson, in his "Methods of collecting and preserving vertebrate animals" (Nat. Mus. Canada, Bull. no. 18, pp. 45–48, 1932) has given excellent instructions about casing skins, there is no need to repeat the details here. The chief points are that instead of slitting the animal up the belly and later sewing this together, cuts are made from the anus to the base of the hind legs, and the skin peeled off like a glove. The skin, after treatment, is then turned back over a stretcher of card cut to the appropriate size and shape, and a flat specimen is produced. The card is usually removed before the skin is stored. Incidentally, the word "stretcher" is rather a misnomer, as it is of considerable importance not to stretch the skin unduly.

The following extensions of this technique have been made. Suppose one has cased a mouse skin: instead of tying a label onto the animal, one leaves sufficient of the stretcher card behind the hind legs to allow the data to be written upon it, and the hind legs and tail to be secured to the card with thread. The base of the card is cut to a standard width that is considerably wider than the mouse. The width used for small mammals, such as mice, is 4 inches. The whole mounted specimen with its card is put inside a cellophane envelope, 4.25 x 11 inches, open at both ends so that the mouse can always be slid in and out with the grain of the fur. The resulting product is a flat specimen of which both sides can be examined without removal from its envelope. It can be removed in an instant if desired, the hind legs and tail are safe from injury, and the records are securely attached to the skin and are visible at a glance. The mounted specimens can then be stored in cabinet drawers or boxes, and classified with guide cards or individually distinguished. This system has especial value where large numbers of skins are being collected for ecological or genetic study, but it may prove also to be of use to the museum expert, provided he does not insist on having round skins for comparative work. The cased skin is inevitably wider than the animal, but this point appears less serious when it is realized that reliable measurements can in any case only be made on the body itself.

There are several other points about the technique of mounting. Casing skins is at least as speedy as any other method, but there is a potential waste of time in cutting cards to the exact size required in each instance. This difficulty is overcome by having a set of flat metal gauges by whose aid the right size of card can be quickly found. It is also convenient to have a supply of cards of different sizes ready cut. Each gauge has a line drawn down the center marked at centimeter intervals, that facilitiates cutting the base of the cards to the right depth to clear the end of the body. The gauges are held together at their base by a central rivet, and they pack into a small space. It is also convenient to have a rubber stamp with the various categories of data required (number, sex, weight) by means of which the base of the card can be stamped, and noth-

ing forgotten. It may be found undesirable sometimes to tie the tail to the card, since this makes it impossible to see the underside. Probably the cellophane envelope will act as sufficient protection if the tail be left free.

The cost of cards and cellophane envelopes is quite small, and is balanced by the great saving in overhead costs of storage and the convenience of reference. When skins are stored in this way, it is probably important that they should be in insect-proof boxes or cabinets. It is not yet known whether they would be less easily kept disinfected when they are inside the cellophane envelopes. It is possible that the card could be treated with some solution and dried, after the manner of insect collection boxes.

In working out this technique, I have received several valuable suggestions from Mr. Francis C. Evans, particularly in regard to gauges and the best shape of card for mounting. Dr. R. M. Anderson has also made some interesting comments. It is hoped that these suggestions may arouse discussion, and in particular elicit the opinions of experienced collectors and museum experts as to whether the preparation of round skins is absolutely essential for taxonomic studies.—CHARLES ELTON, *Bureau of Animal Population, University Museum, Oxford, England.*

SOME ALTITUDE RECORDS FOR MAMMALS IN THE INYO-WHITE MOUNTAINS OF CALIFORNIA

In California the eastern flank of the Sierra Nevada of Inyo and southern Mono counties drops precipitously to the floor of Owens Valley, whence the terrain rises eastward to another lofty and somewhat barren range that is almost as high as the Sierra. The southern half of this more eastern rampart is known as the Inyo Mountains, and the northern half as the White Mountains. The two are imperfectly separated and from the floor of Owens Valley they appear as one continuous chain or lofty ridge, with but few well-marked peaks. Their geology is similar and their faunas even more so.

The entire Inyo-White Mountain massif is in the "rain shadow" of the Sierra Nevada and in consequence is extremely arid. Because of this fact, the various vegetational zones found in this section of the country appear at somewhat greater elevations than usual, and the mammals characteristic of these zones occur at truly astonishing altitudes, considering the ranges of the various species as a whole. During the summer of 1932, a collecting expedition from the Cleveland Museum of Natural History worked in the northern part of this range, while another group crossed the southern part twice during the spring of 1934. Some of the altitude records seem worth recording.

Sorex myops.—Scats of a small shrew, presumably this rare and little-known form, were found on the summit of White Mountain Peak at an elevation of 14,240 feet.

Sorex palustris navigator.—Grinnell (Univ. Calif. Publ. Zool., vol. 40, no. 2. p. 84, 1933) recorded this species from an elevation of 11,600 feet "on the White Mountains." The Cleveland Museum has a specimen from Cottonwood Basin, at 10,000 feet.

Marmota flaviventris fortirostris.—Marmots live in rock outcrops about McAfee Meadow at an elevation of 12,000 feet.

Callospermophilus lateralis trepidus.—Mantled ground squirrels were noted on the summit of Never Summer Mountain, a peak south of White Mountain Peak, at an elevation of 13,000 feet. At 12,000 feet they are abundant all over the range.

Eutamias minimus scrutator.—Common to the upper limit of dwarf sage (*Artemisia nova*), at least to 11,500 feet on Campito Mountain.

Eutamias panamintinus panamintinus.—Noted on the summit of New York Butte, 10,600 feet, in March, 1934. A specimen was taken at about 10,200 feet.

Thomomys bottae melanotis.—Fairly recent workings of this gopher were noted in August, 1932, on White Mountain Peak at 14,000 feet. Its habitat thus covers a range of elevation of 10,000 feet—from the floor of Owens and Fish Lake valleys to the summit

of this mountain-mass. It seems unlikely that gophers could maintain a permanent colony at 14,000 feet, at the upper border of vegetation in typically arctic-alpine surroundings.

Dipodomys microps microps.—A specimen taken at Big Prospector Meadow in 1932 (elevation 10,400 feet) is a truly amazing record.

Peromyscus maniculatus sonoriensis.—Abundant at elevations lower than 12,500 feet. Specimens were taken at this elevation near McAfee Meadow.

Peromyscus boylii rowleyi.—Taken at Sagehen Springs, South Fork of Sacramento Creek, at an elevation of 11,000 feet.

Peromyscus crinitus stephensi.—Found with *boylii* at the above locality, some 3000 feet higher than its previously noted upper limit.

Reithrodontomys megalotis megalotis.—Grinnell (loc. cit.) reported this form from McAfee Meadow at 11,500 feet. We took it at about the same elevation on Sacramento Creek.

Neotoma cinerea cinerea.—Grinnell reported this animal from the summit of Mt. Lyell (13,090 feet), which is considerably more astonishing than a record at 12,500 feet in the White Mountains.

Neotoma lepida lepida.—Taken abundantly at Craig Canyon Pass in the Inyo Range (9500 feet).

Microtus mordax sierrae.—Taken at a point above 12,000 feet, near McAfee Meadow.

Microtus montanus yosemite.—This is a new record for the White Mountains and extends the known range of the form some 50 miles to the east of the Sierra Nevada, across several low, hot valleys. Specimens are at hand from 12,000 feet at McAfee Meadow and from 10,400 feet at Big Prospector Meadow, both in Mono County.

Ochotona schisticeps sheltoni.—This local race of pika goes to the top of the twelve-foot cairn on White Mountain Peak—elevation 14,254 feet. The lowest record is 11,000 feet (Grinnell, loc. cit.).

Lepus townsendii subsp.—White-tailed jackrabbits are unreported for the White Mountains. We saw two at elevations of 12,500 and 13,000 feet, but did not obtain either. They may be of a new race. Grinnell reported the form *sierrae* from the Sierras at an elevation of 13,800 feet.

Ovis canadensis subsp.—Mountain sheep visit the top of White Mountain. We saw them at 13,000 feet on Boundary Peak (Mineral County, Nevada) and at 13,900 feet on White Mountain Peak. The race is probably *sierrae*, according to Grinnell (loc. cit., p. 210).

Odocoileus hemionus inyoensis.—It is presumably this race of deer that we noted in Olmsted Basin just to the northeast of White Mountain Peak. The elevation was about 12,300 feet. In all probability the animals go much higher than this.—B. P. Bole, Jr., *Cleveland Museum of Natural History, Cleveland, Ohio.*

DISTRIBUTIONAL RECORDS FROM KANSAS

Recent distributional records have served appreciably to extend the known range of 3 species of Kansas mammals. Skulls of *Cryptotis parva* and *Sigmodon hispidus* were found in owl pellets by C. W. Hibbard (1937) near Meade, Kansas. Specimens of *Sigmodon*, taken later at the same locality, proved to be *Sigmodon hispidus texianus*. These records extend the known Kansas range of both species more than 100 miles to the west.

Citellus spilosoma major, first taken in Morton county, Kansas, during 1927 by L. V. Compton, had not been recorded subsequently until W. S. Long (1934) took one specimen in Seward County, about 60 miles farther east. This subspecies, upon further collecting in the southwestern part of the state, will very likely prove to be a rare inhabitant of several other of the southwestern counties.—James M. Sprague, *Museum of Birds and Mammals, Lawrence, Kansas.*

HAIRY-TAILED MOLE IN VIRGINIA

While engaged in food-habits studies of snakes collected in the George Washington National Forest, the writer took a nearly whole specimen of hairy-tailed mole (*Parascalops breweri*) from a copperhead snake (*Agkistrodon mokasen*) secured July 16, 1936, at CCC Camp Todd near Mount Solon, Virginia. The mole was in good condition and its identity was easily established. Later, Ray Greenfield, also of the Biological Survey, took two more specimens of this mole from the same species of snake, one collected in George Washington National Forest on June 27, 1937, at 1 P.M. in the yard of CCC Camp F-2, Augusta County, Virginia, and the other on July 12, 1937, at 6:30 P.M. at CCC Camp NF-8, Little Fork Road, Pendleton County, West Virginia. The files of the Biological Survey contain only two previous records of the occurrence of this mole in Virginia, one from Mount Rogers (June 26, 1903) and the other from Mountain Lake (June 12, 1913).—LAWRENCE W. SAYLOR, *Section of Food Habits Research, Bureau of Biological Survey, Washington, D. C.*

NORTHERN SMOKY SHREW IN VERMONT

Three northern smoky shrews, *Sorex fumeus umbrosus*, have been taken in Vermont during the last two years. The first two were secured August 3, 1936, at Brighton by Robert Chaffee, Victor Cutter, Robert Cheney of the Dartmouth College Museum, G. H. Ross and myself. One of these is in the Dartmouth Museum, the other is no. 679 in my own collection. The third specimen was taken at St. Albans, in the Champlain Valley, June 21, 1937, by G. L. Kirk of Rutland. Kirk's specimen was checked by H. H. T. Jackson and returned marked *umbrosus*. The Brighton and St. Albans skins agree in coloration. These are the first Vermont records, as far as we have been able to determine.—F. L. OSGOOD, JR., *Rutland, Vermont.*

FEEDING HABITS OF THE LEAST SHREW

The least shrew, *Cryptotis parva*, is generally considered rare in Michigan, for until recently it had been taken but seldom. Within the past two years, however, a fair number of specimens have come to me from Oakland County, without any special effort on my part. Three of them were from the campus of Cranbrook, Bloomfield Hills, and two from the areaways around cellar windows in a residence at Lake Angelus, northeast of Pontiac. In both situations the land is hilly, considerably cultivated, but planted with shrubbery and small trees.

A living specimen was brought to me on November 10, 1937, by Robert R. McMath and Harold E. Sawyer, from Lake Angelus, as their observations led them to suspect that the feeding habits of the shrew might prove of interest to a mammalogist. This individual, which had been in captivity for one day when I first saw it, was confined in a can ten inches in diameter. I introduced a medium-sized leopard frog into the container. The shrew immediately approached the frog, appeared to sniff at it from several angles, and then rushed up to nip the frog's knees. The frog responded vigorously by kicking and the shrew carefully dodged the kicks, but repeatedly attacked each knee of the frog. The frog continually cried aloud and attempted to escape, which of course it was prevented from doing by the sides of the can. After a number of attempts the shrew severed the patellar tendons and thus rendered the frog helpless. The shrew then proceeded to eat the frog.

A new-born house mouse, *Mus musculus*, was offered to the shrew before the frog was introduced, and was examined but not molested.

The following day the shrew was photographed in both still and motion pictures, but it disliked the strong lights employed. The morning of November 12 it was dead, having consumed in the 60 or so hours of its confinement at least two moderate-sized leopard frogs and several grasshoppers and crickets.

I am informed by Messrs. McMath and Sawyer that the shrew employed the same technique in subduing grasshoppers and crickets as it did with the frog; biting the joints of the largest legs.

Mr. McMath has kindly furnished me with his observations on the shrews at his residence, and since they are based on a more normal situation and on greater numbers, I here quote him.

"As you know my home is in the country. We have a large number of areaways built around our cellar windows. These all act as natural collecting pits. Just as the first cold weather set in this fall, each areaway collected from ten to thirty frogs.

"One night I heard a tremendous commotion in one of the areaways and took the flashlight to the window in an effort to see what was going on. I noticed three small animals chasing one frog—which frog seemed to be in great distress. Mr. Harold Sawyer was with me at the time. We killed two of the animals and damaged the third one in an endeavor to secure it alive. We also caught the frog which had been the object of the attack. The shrew was identified as *Cryptotis parva*.

"An examination of the frog showed that each shrew would dive underneath the frog and attempt to hamstring it at the knees." [At Cranbrook the shrew approached from the side; did not dive under the frog.] "In other words the behavior of each shrew observed was practically identical and they were not doing something unusual at the time we observed them. On subsequent evenings we found other shrews attacking the frogs in exactly the same way."

It appears from the above that the least shrew feeds habitually on frogs, grasshoppers, and crickets, and that it has a special technique associated with the habit of feeding on these leapers. The fact that one of the shrews refused a young mouse raises the question as to whether or not warm-blooded animals are eaten by *Cryptotis parva*.—ROBERT T. HATT, *Cranbrook Institute of Science, Bloomfield Hills, Michigan.*

TWO NEW OREGON LOCALITIES FOR TWO RACES OF PALE BATS

Specimens of two subspecies of bats, *Antrozus pallidus cantwelli* and *Corynorhinus rafinesquii pallescens*, both pallid bats rarely reported from Oregon, were found by members of the 1937 Catlow Cave Archeological Expedition of the University of Oregon.

Catlow Cave lies in Harney County about 110 miles almost due south of Burns, Oregon, while Roaring Springs Cave is approximately 30 miles nearer Burns along the same road.

Both caves were made by wave action against the igneous rock when a great Pleistocene lake at the pluvial period filled the now dry valley. Their elevations are approximately 4760 feet, and they are about 200 feet above the valley floor on the east shore line which forms the western escarpment of the Steens Mountain massif.

Catlow Cave, a huge westerly facing shelter about 110 feet wide by 40 feet high, with a maximum depth of 60 feet, curves upward and out like the proscenium arch of a theatre. Large rocks high in the front center of the roof have been loosened and provide a resting place for bats. The cave is light at all times, but not exposed to the sun until afternoon, when it is gradually filled with sunlight and its coolness changes to an almost unbearable heat.

From Catlow Cave no. 1 came 7 specimens of *Antrozous pallidus cantwelli*. The bats disturbed by our party on the morning of June 25, 1937, flew about in the bright daylight and one of the females dropped a newborn young with the placenta still attached. This young bat lived all day with seemingly no diminution of vigor or voice. The temperature the night before had been about freezing, and during the afternoon was approximately 90 degrees F.

On July 6 a charge of fine shot was fired into the fissure, bringing down two young,

and one mother and young subsequently fell and were recovered. The young bats were very agile in crawling up the rough rock walls, but on level ground progressed with great difficulty by a series of fluttering hops, and only under urging.

Several portions of the roof of Catlow Cave had probably been occupied by bats in previous times. The cave has known human occupancy for several thousand years, and between the human culture levels at certain places were found extensive, hard-packed deposits of bat guano, from one to three inches thick. Specimens of *Antrozous pallidus* skulls were found in almost all layers of the floor deposit.

The Roaring Springs Cave is very low and dark, 20 feet across the front and running back about 35 feet to a point. Indians occupied it, but since it has not yet been excavated neither the period of human nor of chiropteran occupancy has been determined. On the roof of this cave on July 24, 1937, were found a few specimens of *Corynorhinus rafinesquii pallescens*, hanging singly, which flew out at our entrance. Three females, however, with one young each, were caught and preserved. The young bats still were attached very tightly to the mothers' mammae, and hung rather loosely with their digits, although they were almost capable of independent flight, staying aloft for 30 feet or more when released from the hand.

Specimens nos. 1 to 9, 12, 13 are in the vertebrate collections of the Museum of Natural History of the University of Oregon, while nos. 10 and 11 (from Roaring Springs Cave) are in the Museum of Vertebrate Zoology of the University of California.—L. S. Cressman, *Department of Anthropology, University of Oregon, Eugene, Oregon, and* Charles A. Reed, Jr., *Department of Biology, University of California, Berkeley, California.*

NOTES ON THE BREEDING OF LASIURUS AND PIPISTRELLUS IN PENNSYLVANIA

Since recording the breeding of *Lasiurus cinerea* in southeastern Pennsylvania in 1932 (Jour. Mamm., vol. 13, p. 365, 1932), Dr. H. J. Roddy, of Franklin and Marshall College Museum, has shown me 3 specimens, a female with 2 young, male and female, captured on June 14, 1933, while clinging to the foliage of a cherry tree in Lancaster. The young had their eyes open and were clinging to the teats of the female.

Measurements of one of the young (total length, 92 mm., forearm, 50), indicate that these were about one-half grown, and that they must have been born fully 2 weeks previous to their capture. Lancaster is 30 miles west-southwest from Hopewell, Berks County, Pennsylvania, where the previous specimens were taken.

On July 8, 1934, Lester Leinbach, while removing a large net that had been hanging since the preceding winter in a barn near Leesport, Pennsylvania, disturbed a number of pigmy bats that had been using the folds of the net as a roosting place and nursery. Most of the bats escaped upon being disturbed, with the exception of 3 adults and 6 young, which were captured and brought to the Museum.

Upon comparison with a large series of *Pipistrellus* in this collection, the adults appear to be atypical specimens of *P. subflavus subflavus*. One of these contained 2 embryos, which, unfortunately, were not weighed, but they were covered with fine hair and in a condition that denoted birth within a very short time. Of the 6 young taken at the same time, 3 were males and 3 females. All had their eyes open, but were unable to fly, except to raise themselves a few inches from the floor. Their weight varied from 3.20 to 3.80 grams. Adults at this season weighed from 4.35 to 6.50 grams. The linear dimensions of the largest young were about five-sixths those of a large adult, so that it seems probable that the oldest were between 2 and 3 weeks old.—Earl L. Poole, *Reading Public Museum, Reading, Pennsylvania.*

GESTATION PERIOD IN THE LONG-TAILED WEASEL

The first positive evidence that came to my attention that weasels of the subgenus *Mustela* have an unusually long period of gestation was Hamilton's (Amer. Midland

Nat., vol. 14, p. 315, 1933) record of a period of at least 70 days in *Mustela frenata noveboracensis*. Tichwinski's recording (Jour. Mamm., vol. 18, p. 515, 1937) of a period at least 104 days long in the related species *Mustela erminea*, induces me to place on record a period of at least 131 days for *Mustela frenata nevadensis*. The female concerned was captured and caged January 13, 1937, 4 miles south of Tahoe City, California, and on the following May 24 or 25 gave birth to 4 young at Berkeley, California.—E. RAYMOND HALL, *Museum of Vertebrate Zoology, University of California, Berkeley, California.*

THE WEASEL AS AN ENEMY OF THE PIKA

On July 14, 1937, I was collecting pikas (*Ochotona princeps nigrescens*) from a small rock slide in Cumbres Pass, Conejos County, Colorado. This locality is in the southern end of the San Juan Mountains, at an elevation of about 9000 feet, and 14 miles north of the New Mexico line.

Pikas here were uncommon and extremely shy. Although two or three were heard calling, they were in the tumbled masses of rock and did not show themselves. After some time I sat down upon a boulder near the spot where I had heard the last call a few minutes previously, hoping that the animal would show itself. Shortly I began "squeaking", with almost immediate results. In less than a minute a brown streak shot across the face of the slide just below me, and a weasel (*Mustela* sp.), thrust head and shoulders from behind a rock less than 10 feet away. It stared at me for a moment before darting under a rock and out of sight. It had come from a point at least 30 yards to my left.

Soon I heard a long-drawn-out sound, neither a groan nor a squeal, yet having some of the qualities of both. It was totally unlike the usual bark of a pika, but was unmistakably made by that mammal. My impression at the time was that it was an exclamation of pure terror. Almost at the same instant a pika darted from a crevice at my feet, ran over the surface of the slide for about 25 feet, and again disappeared in the rocks, repeating the peculiar sound. A chipmunk (*Eutamias* sp.) also fled from the rocks at the same time. Although I "squeaked" at intervals for another 10 minutes, neither the weasel nor the pika was seen again.

There is little doubt that this weasel, and possibly a pair of them, had been living in or near this slide and preying upon the other small mammals finding shelter in the rocks. Weasels are quite common in the mountainous parts of Colorado, and undoubtedly they are the most important enemy of the pika, in this region at least.—W. S. LONG, *830 East Platte Avenue, Colorado Springs, Colorado.*

THE DECLINE OF A MINK POPULATION

The decline of mink (*Mustela vison*) in western Brookings County, South Dakota, has been pronounced since my youth, and fairly well reflected, I think, by notes made on catches and other matters of outdoor interest over a period of years while I was trapping for fur. My hunting and trapping activities in Brookings County covered the years between 1915 and 1928, with time out for intermittent attendance at school, work, and hunting and trapping expeditions elsewhere. My trapping was confined chiefly to two main areas; one was about 7 square miles of the Oakwood and Tetonkeha series of lakes and marshes west of Bruce; the other was the vicinity of the Sioux River running through about 4 square miles of bottomland west of Brookings.

My written notes were begun in 1919. As a boy, I caught some mink, but I recall that the animals were both numerous and generally too wary for me. It was not until the winter of 1919–1920, when I caught 6 mink along about 2 miles of the Sioux River, that my trapping became sufficiently skillful for my catches to be any criterion of numbers present. So far as I could see, the mink "sign" in areas with which I was familiar remained about the same from 1917–1918 to 1921–1922, the latter being the last winter of conspicuous abundance.

My usual procedure was to trap both lake and river areas as long as the trapping was at all worth while, or until terminated by the closing of the legal season. This commonly meant two or three months each winter spent on the trapline. Other fur animals besides mink were sought, but the mid-winter trapping in Brookings County was practically for mink alone.

I did no trapping in Brookings County during the winter of 1920–1921, but my mink catch was 19 for 1921–1922 and 13 for 1922–1923. In 1923–1924, I was in college and too busy to trap for more than one month, which I devoted mainly to muskrat trapping, so my small catch of 3 mink is not of much use for comparison; but the mink population was low, nevertheless. In 1924–1925, I was in another part of the state. During the Christmas holidays, 1925, I caught 7 mink in a little over a week in my old lake territory, and just about cleaned it out. In 1926–1927 and 1927–1928, the most diligent trapping I could do brought me 4 and 5 mink, respectively, which may be compared with the catches for 1921–1922 and 1922–1923.

The catches of other trappers whom I knew personally dropped roughly in proportion to mine, although I do not have many exact figures on this point. To me, at this distance, the decline looks like a simple case of exploitation by man, but we know too little of the population phenomena of wild animals to be positive. The recent great drought did not come until later, nor was it until later that state legal protection of the mink as a game animal, with definite open and closed seasons, was withdrawn.

The fur trapping—mine included—doubtless contributed materially, but hunting mink by means of dogs became popular in 1921–1922 and in the years immediately following, and surely accelerated any decline that may have been taking place previously. It was estimated at the close of the 1921–1922 open season that approximately 200 mink had been taken that winter from about 12 square miles of the Oakwood and Tetonkeha neighborhoods—an estimate that now impresses me as being somewhat high, although it was computed on the basis of known catches of hunters and trappers and the opinion of the chief local fur buyer. I happened to be one of the two trappers with the heaviest mink catches, but our combined catch about the lakes was 28, or decidedly less than the 39 mink taken by a neighbor with a trained dog. Other mink dogs of lesser repute were credited with from 3 to 15 mink for the season, whereas farm boys and other relatively inexperienced trappers were lucky to get from 3 to 5 mink with traps, and usually caught only 1 or 2, if any.

The trapping seasons during the years referred to opened on the first day of December, by which date the South Dakota climate seldom permitted use of the easily made and effective open water "sets". The seasons also closed sufficiently early to afford trappers few opportunities to take advantage of the increased activities and decreased wariness of mink during the March mating. Consequently, much of the trapping had to be done for animals that were more or less trap-wise on land, and living in habitats in which alternate thawing and freezing and blowing of snow made useless large numbers of prospective trap sites. Under these conditions, even experienced trappers, out to get all they could, frequently left a fair breeding stock behind them when they were through or the season closed.

On the other hand, hunting with dogs in combination with digging of animals out of their places of refuge, added to the trapping pressure, was seemingly more than the mink could endure and still maintain their former numbers. It is difficult to evaluate the effect of a wholesale destruction of retreats, including prospective breeding dens, but it is at least plain that the advent of men with dogs and digging tools accompanied the lowering of mink population densities in the areas indicated.—PAUL L. ERRINGTON, *Iowa State College, Ames, Iowa.*

A WISCONSIN SPECIMEN OF THE COUGAR

The Neenah and Menasha "Conservator", December 17, 1857, stated that Samuel B. Hart of Appleton killed a "huge panther" on November 22. The Appleton "Crescent", December 12, 1857, carried a circumstantial account of this event. Samuel P. Hart, with a neighbor, was searching for a colt when his dog treed the cougar. The animal measured 7 feet 2 inches in length. "Two of his tusks, one of the upper and the other of the lower jaw, were broken off, and had apparently been gone for several years. The other two tusks were very large but much worn." The specimen was mounted by "Prof. Mason and Dr. Beach". An accompanying article on "Lawrence University Cabinet" stated: "As you enter the room the first object that attracts attention is the Panther recently transferred from a savage roaming life, to one more congenial to the wishes of the people".

On inquiry, Professor Walter E. Rogers, of Lawrence College, informed me that this specimen is still in existence and measures 27 inches in height at the shoulders and 85 inches in length from the end of the nose to the tip of the tail. The card accompanying the specimen reads as follows: "Killed by Mr. Reese in 1848 on the Randall Farm, two miles north east of Appleton. He was searching for a lost horse in the snow, and found panther tracks. The following day he went on horseback, tracking the animal through the snow, finally killing him near the Ballard Road."

A photograph of the cougar, furnished by Mr. W. H. Johnston of the College, shows that the upper right and lower left canines are missing. The condition of the teeth, close agreement in length, and other data leave little if any doubt that the specimen represents the cougar killed in 1857 at Appleton, by Samuel P. Hart. Insofar as known it is the only Wisconsin specimen of *Felis concolor cougar* extant.—A. W. Schorger, *168 North Prospect Avenue, Madison, Wisconsin.*

PARASITES OF SOME MINNESOTA RODENTS

During the year 1936 I was engaged in a survey of the parasites of Minnesota wild mice. The house mouse, *Mus musculus*, was included because it is feral in several localities. Most of the mice were trapped in Pine, Hennepin, Ramsey, and Anoka counties. Eighty-eight mice of 6 species were examined for parasites: 18 jumping mice (*Zapus hudsonius hudsonius*), 18 meadow mice (*Microtus pennsylvanicus pennsylvanicus*), 23 Canadian deer mice (*Peromyscus maniculatus gracilis*), 5 northern white-footed mice (*Peromyscus leucopus noveboracensis*), 3 red-backed mice (*Clethrionomys gapperi gapperi*), and 21 house mice (*Mus musculus*).

Of the 18 jumping mice examined, 3 were parasitized. One specimen harbored 14 nematodes of the genus *Subulura* in the cecum and esophagus and 27 nematodes of the genus *Spirocerca* in the small intestine, stomach, and lungs. In the abdominal wall of a second specimen, a dipterous larva, *Cuterebra* sp., was imbedded. In a third specimen, from the Michigan Biological Station at Douglas Lake, a new fluke of the genus *Notocotylus* was found.

Two internal parasites were recovered from the northern white-footed mouse—one specimen of an undetermined species of larval cestode, and 44 nematodes of a new species of the genus *Syphacia*. Three external parasites were also taken from the northern white-footed mouse—two fleas, *Monopsyllus wagneri* and *Neopsylla* sp., and a sucking louse, *Haemodipsus* sp.

Four of the Canadian deer mice were infested with a new species of cestode of the genus *Prochoanotaenia*. In addition, 3 nematodes of the genus *Aspiculuris* were found in one Canadian deer mouse. These nematodes differ in one or more respects from the 3 known species of the genus. Finally, 3 specimens of Acanthocephala, *Moniliformis* sp., were taken from the deer mouse.

From the meadow mouse, *Microtus*, cestodes of the genus *Paranoplocephala* were recovered, and frequently the nematode *Syphacia obvelata*, as well as the following external parasites: *Liponsyssus* sp., *Ctenophthalmus pseudagrytes*, and *Haemodipsus* sp.

A cestode of the genus *Paranoplocephala* was removed from the cecum of a red-backed mouse. This cestode is found in *Microtus* also. Two species of nematodes, *Syphacia obvelata* and *Aspiculuris tetraptera*, were recovered from the house mouse.—Arnold B. Erickson, *National Park Service and Department of Zoology, University of Minnesota, Minneapolis, Minnesota.*

NOTE ON AMERICAN HOUSE MICE

The systematic status of the house mouse in North America is not well known, but its development on this continent presents interesting problems. A very brief summary of recent comparisons seems worth recording, although I have reached no systematic conclusions more concrete than Harper's (Jour. Mamm., vol. 11, p. 49, 1930).

A series of the large, gray, ubiquitous form which we are accustomed to call *Mus musculus musculus* (Zimmerman, Zeitschr. Zäug., vol. 10, p. 156, indicates the possible inapplicability of this name) was obtained in Devonshire, England. Regardless of any hypothetical genetic constitution, this form is represented by the greatest number of individuals in most of the collections of American *Mus* that I have seen (principally in Washington, Philadelphia, New York, and Cambridge). I assume (for practical purposes and with reservations) that it was principally this form that gave rise to the American hodge-podge. I used the Devonshire series as a basis for comparing the various New World divergents.

The American specimens that I have examined fall into three groups:

1. Those indistinguishable from the Devonshire series; usually most abundant in well-populated areas and north of the Mason and Dixon Line.

2. Those presenting slight variation from the Devonshire typical *M. musculus*, but which are not yet sufficiently divergent to merit racial distinction; occurring principally in rural areas and below the Mason and Dixon Line. The most obvious of these variations is a group (author's collection) from the southern end of the Cape Charles Peninsula that averages smaller than the Devonshire series, has a proportionately shorter tail, and a greater amount of yellow pigment which gives to the upper parts a warmer appearance. Another well-marked local group, in the Museum of Comparative Zoology collection, came from Sterling, Georgia. These mice show greater development of reddish pigment throughout than the Devonshire series, and tails that are proportionately shorter.

3. Strictly bicolored individuals, pairs, or trios that appear at practically any point within any of the groups mentioned above. Morphologically these are very similar to the European *spicilegus* variant (the value of which name is under discussion by German, French, and Russian taxonomists).

The single character *bicolored* apparently occurs without linkage to any of the differences in average measurement and shade of pelage mentioned above. It seems to act like an independent mutation, occurring in places sufficiently removed from centers of transportation to make the possibility of its having been brought from Europe as a distinct *spicilegus* (or *hortulanus*) seem fantastic.

For the taxonomist the American *Mus* are still a nightmare; but larger series and collections of whole populations will undoubtedly fit them into an orderly arrangement. The binomial designation on most *Mus* labels throughout our country is a challenge that will not be met halfway until we have series comparable to our pet *Peromyscus*.—David G. Nichols, *Garden City, New York.*

NAPAEOZAPUS INSIGNIS IN VIRGINIA

While examining reptile stomachs in the Food Habits Laboratory, Bureau of Biological Survey, for the U. S. Forest Service, I discovered a specimen of the woodland jumping mouse (*Napaeozapus insignis*) in the stomach of a rattlesnake (*Crotalus h. horridus*) collected on July 9, 1937, in the George Washington National Forest, Augusta County, by CCC workers under the supervision of T. E. Clarke. This discovery constitutes the first record of *Napaeozapus* from the State of Virginia. The identification was verified by Dr. H. H. T. Jackson and the animal has been deposited in the mammal collection of the Biological Survey.

Another specimen of the same species was taken by L. W. Saylor of the same Laboratory from the stomach of a copperhead (*Agkistrodon mokasen*), also collected in the George Washington National Forest.—RAY GREENFIELD, *U. S. Biological Survey, Washington, D. C.*

SEXUAL DIMORPHISM IN NAPAEOZAPUS

C. H. D. Clarke (Canadian Field Nat., vol. 49, p. 139, 1935) stated that he observed a marked sexual difference in the amount of white exhibited on the tail-tips of *Napaeozapus*, males having a larger amount of white than females. This led me to compare a series of 98 adult skins of this genus from the New England states. Measurements of all but 30 were obtained in the flesh and were taken from a point where the white pigment begins on the dorsal surface of the tail to the end of the fleshy portion, but does not include the pencil. Forty-six females average 19.38 mm. (0-42); 52 males average 17.2 mm. (2-37). It will be noted that there is a considerable range of variation in each sex, the maximum and minimum ranges being approximately equivalent for each. It seems reasonable to conclude from these data that no such sexual difference is manifest in specimens from New England.—NORMAN A. PREBLE, *73 Prospect Street, Wakefield, Massachusetts.*

REVIEWS

Scott, William Berryman. A HISTORY OF LAND MAMMALS IN THE WESTERN HEMISPHERE. Second edition revised, 1937, i-xiv, 1-786 pp., 420 figs. The Macmillan Co. Cloth, $7.50.

After almost 24 years there appears a new edition of Professor Scott's monumental work, in large part rewritten and with the incorporation of the immense amount of new paleontological information that has accumulated during the last quarter century. It is one inch shorter than the old edition, which should be a useful feature. The book is frankly intended for a public between the professional paleontologist and the lay public, and as a concession to this class the treatment of the phyla begins with recent forms and works back.

The reader will be disappointed to note that a number of the less numerous, as well as the smaller groups, as rodents and insectivores, to mention two, are almost ignored. It is true that material of this category is scanty or in some cases largely unworked, but they should receive more attention in a book of this scope. The outline of the head of a recent sperm whale superimposed on its skull is faulty, for in this form the head projects far beyond the bony rostrum. In addition, erroneous or obsolete generic names of Recent mammals have not been corrected from the first edition: *Alce* for *Alces*, *Myodes* for *Lemmus*, *Fiber* for *Ondatra*, *Sitomys* for *Peromyscus*.

No other book on the subject combines authoritativeness with the fascination of fossil-hunting to an equal extent, and Professor Scott has earned a generous portion of gratitude.—A. B. HOWELL.

Darling, F. Fraser. A HERD OF RED DEER; A STUDY IN ANIMAL BEHAVIOR. Oxford University Press, London, December 16, 1937, pp. i–x, 1–215, 7 plates, 10 text figures, 4 maps. Cloth, $5.50.

This is a very charmingly written book, recounting in simple plan the results of a two-year study of the red deer of an area in northwestern Scotland. One is impressed with the common-sense reasoning of the author and his unwillingness to jump to spectacular conclusions. The result is a book that contributes greatly to the human understanding of the largest game animal of Great Britain.

The red deer is a species closely related to the American wapiti, and in this part of Scotland at least it may be considered as having throughout several hundred years attained a condition of ecological balance in respect to man such as today is hardly to be encountered among the wapiti of America, harassed as they are by the curtailment of either winter or summer range, or both, and by the veering winds of political expediency and demands of sportsmen. Of particular value are the data upon the reactions of the deer to sudden changes in temperature, humidity, and other environmental conditions—data that may, with profit, be used as yard-sticks in the study of the deer of other areas throughout the world.

The price, for a book of this size, seems rather exorbitant, and will deter many from its purchase.—A. B. HOWELL.

de Beer, G. R. THE DEVELOPMENT OF THE VERTEBRATE SKULL. Oxford University Press, 1937, pp. i–xxiii, 1–552, 143 plates. Cloth, $10.00.

This scholarly book is the result of 15 years of research on the subject by one who is eminently well fitted for the task. For the first time the development of the skull of all classes of vertebrates has been integrated on a single basic plan of treatment. It is not a book for him who cares only for the topography of the adult mammalian skull. It is an "advanced" work, and the reader must be already familiar with the terminology and fundamental facts of craniogenesis, but for one who desires a thorough understanding of the skull, it is indispensable.

The introductory (39 pages), comparative (69 pages), and general (64 pages) sections, the last comparing the embryology with the phylogeny, consist of general accounts and discussions, and it is these parts which the reader will peruse with profit. The remainder (334 pages) consists of a systematic section that will be used largely for reference.

The chondrocranium is the feature particularly stressed. It is concluded that the chondrocranium of different vertebrate classes exhibits no essential recapitulation in its plan, and that it is largely devoid of phylogenetic significance as between the classes. In mammals it is very uniform in basic features. It is stated that the chondrocranium and osteocranium probably evolved largely independently, although necessarily in association.

The report is based on a quite remarkable amount of material, including numerous representatives of all orders of living mammals except Proboscidea, Hyracoidea, and Tubulidentata.—A. B. HOWELL.

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OBITUARY NOTICE

ARTHUR JAMES POOLE

Arthur Poole, charter member of the American Society of Mammalogists, died suddenly on July 3, 1937, while visiting at the home of his brother in Vineland, New Jersey, the town of his birth. He was born the son of Arthur W. and Emma (Chew) Poole, on August 24, 1889. In 1924 he was married to Marguerite Woodward of Washington, D. C., who survives him.

Poole joined the staff of the U. S. National Museum on December 16, 1914, as cataloguer in the Division of Mammals; was transferred to the U. S. Biological Survey, March 31, 1916, and reinstated in the U. S. National Museum, November 1, 1916, as stenographer-typist, being promoted to scientific aid, July 1, 1927, in which capacity he continued until the time of his passing.

He made two collecting trips to Haiti for the Smithsonian Institution, and four trips to Wisconsin for the Wisconsin Geological and Natural History Survey and the U. S. Biological Survey.

From 1921 to 1931 he served as Treasurer of the American Society of Mammalogists. Poole and the undersigned had at the time of his death nearly completed the manuscript for a new edition of the "Catalogue of type specimens of mammals in the U. S. Biological Survey and U. S. National Museum collections", first composed by Lyon and Osgood, and published in 1909. His publications are as follows:

Guide to type localities, U. S. Nat. Mus. Bull. no. 128, pp. 517–603, April 29, 1924.

The number of forms of recent mammals. Jour. Mamm., vol. 7, pp. 134–135, May, 1926.

Further exploration of Haitian caves. Explorations and Field-work of the Smithsonian Institution in 1928, pp. 55–62, 1929.

Explorations in Haitian caves. Explorations and Field-work of the Smithsonian Institution in 1929, pp. 63–76, 1930.

The number of forms of recent mammals. Jour. Mamm., vol. 17, p. 282, August, 1936.

His many friends miss his amiable personality, and to the National Museum his detailed knowledge of the mammal collection and his talent for the arrangement and care of the material under his charge is a very great loss.—VIOLA S. SCHANTZ.

COMMENT AND NEWS

Because of the impracticability of submitting proof of their articles to authors living in distant parts of the world, the chance of distorting the author's meaning is more than ordinarily apt to be accomplished by editorial alterations. It is regretted that two such instances occur in Hubback, T. R. The Malayan gaur or seladang. Jour. Mamm., vol. 18, no. 3, pp. 269, 278, August, 1937. It was stated (page 278, line 5 from the bottom of the page) that the hunting of gaur is now highly commercialized. Instead it should have been said that the country, not the hunting, is now commercialized. On page 269, line 6, for diameter, of horn base, read circumference.

Members desiring reprints of the "List of Recent Literature", appearing in each number of the JOURNAL, may secure them from the treasurer at a cost of 18 cents each, or 70 cents per volume. Back numbers since 1930 are available at the same rate.

Plans are being made to hold an exhibition of photographic studies of living wild animals in their native habitats as a feature of the annual meeting of the Society to be held in Berkeley, July 19 to 23, 1938. Prints should be 8 x 10 or 11 x 14 inches in size, uncolored and mounted on plain white mounting paper, 16 x 20 inches, so that they may be exhibited under glass in the University Art Museum on the Campus. Members are requested to send, carriage prepaid, their outstanding animal prints, with subject, photographer and date indicated on the back of each mount. For further information address Joseph S. Dixon, 330 Hilgard Hall, University of California, Berkeley, California, in whose care prints may be sent until June 25.

The chairman of the Editorial Committee, A. Brazier Howell, will be absent from his office from the last week in June until the first of September. During that time all correspondence relating to articles for JOURNAL OF MAMMALOGY should be addressed to Arthur H. Howell, National Museum, Washington, D. C.